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HARPOON EXPENDABLE TURBOJET MODEL XJ401-GA-400

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AiResearch Manufacturing Company of Arizona

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HARPOON EXPENDABLE TURBOJET MODEL XJ401 GA-400

PHASE II FINAL TEST REPORT AND FINAL REPORT

(30 June 1971 to 13 April 1973)
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THIS REPORT CONTAINS A SUMMARY OF THE ACTIVITIES OF THE HARPOON PHASE II ENGINE PROGRAM. (U)

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HARPOON EXPENDABLE TURBOJET
MODEL XJ401-GA-400
PHASE II FINAL TEST REPORT
AND FINAL REPORT

1.0 INTRODUCTION

This report is submitted by the AiResearch Manufacturing Company of Arizona, a division of The Garrett Corporation, in compliance with the contractual data requirements of U.S. Navy Naval Air Systems Command (NASC) Contract N00019-71-C-0358. This report documents Phase II of the development of a turbojet propulsion system for the Harpoon missile and covers the period from 30 June 1971 through 13 April 1973. The engine is designated as the Model XJ401-GA-400 Expendable Turbojet.

The objectives of the Phase II development program were:

- o Design, fabrication and development of engines suitable for wind tunnel and flight testing.
- o Delivery of above engines to the Weapons System Contractor.
- o Technical liaison with the Weapons System Contractor, including systems test support.

Initial flight rating tests (IFRT) verifying the performance requirements defined in AiResearch Model Specification SC-8029-A, dated 30 November 1972 have been completed. Final IFRT test results are presented in 5.0.

2.0 SUMMARY

Phase II of the development program for the Harpoon propulsion system was started on 30 June 1971. Work on this phase of the program was initiated by a letter modification to the U.S. Navy, Naval Air Systems Command (NASC), Contract N00019-71-C-0358, C/N 0888-71. Major goals to be completed during this phase of the development program, as defined in the program plan published in August 1971, were:

- Flight Engine Design Release
- Contractor's Development Tests
- Initial Flight Rating Tests
- Wind-Tunnel Engine Design Release
- Technical Liaison
- Delivery of Mockups, Wind Tunnel, and Flight Test Engines

A chronological review of significant development achievements includes the following:

- July 1971 - Installation interfaces established.
- August 1971 - Engine cycle computer programs were finalized. Prototype engine cross section installation and casting drawings were completed.

- September 1971 - Final drawings of turbine, compressor, seals, and bearings test rigs were completed and rig fabrication started.

- October 1971 - Evaluations of engine component and accessory designs completed. Rig testing commenced and the first mockup was submitted for review.

- November 1971 - Stress analyses of major structural elements was completed. Rotor dynamics were established. Thermal analyses were started and several development rig tests were completed. A second mockup was coordinated and delivered to the airframe manufacturer.

- December 1971 - Flight engine design was completed. The first scheduled run of the engine was concluded satisfactorily.

- January 1972 - The engine demonstrated thrust and TSFC meeting analytical model requirements. Successful compliance with model-specification requirements for circumferential distortion was demonstrated.

- February 1972 - Electrical system endurance tests completed satisfactorily. Development tests of accessories and components in engines and rigs evaluated.

- March 1972 - Completed acceptance testing of wind-tunnel engines. Started assembly of IFRT engines.

- April 1972 - Wind-tunnel testing commenced. The IFRT vibration survey was conducted.

- May 1972 - Three series of tests were concluded with engines installed in the McDonnel-Douglas ETB Harpoon Missile in the 8 x 6 wind tunnel facility of the NASA-Lewis Research Center, Cleveland, Ohio.

  Three IFRT tests were also completed. They were the 0.6 simulated Mach number altitude start, high temperature start and inlet air pressure variation.

- June 1972 - Five more IFRT tests were completed. The tests consisted of an altitude start (0.38 Mach number) and sea level endurance, two sea level endurance tests, high-temperature start and sea level endurance, altitude start (0.6 Mach number) and sea level endurance.

  Captive flight tests of the engine installed in the Harpoon missile were conducted at altitude on the P-3A aircraft at the Naval Missile Center, Point Mugu, California.

- July 1972 - Development and investigatory tests were conducted on bearings, the fuel control and starting system.

- August 1972 - Development and investigatory tests continued. Special emphasis placed on dynamics of rotating components, shaft assembly and seals.

- September 1972 - Based on intensive development test experience, several design refinements were incorporated. Tests conducted to verify these refinements included six successive 30 minute engine endurance runs at design conditions. IFRT requirements for completion provided by NASC.

- October 1972 - Development tests with new configuration hardware continued. Engine tests were conducted to confirm the ability of the engine to make consistent successful starts at IFRT test conditions. Fuel control development tests were expanded to include test demonstrations with an electronic control unit.

- November 1972 - The excellent test results achieved with the electronic control led to its adoption in lieu of the fluidic control. Design modifications were completed for incorporating the electronic control into the final engine configuration. SC-8029-A engine specification issued.

- February 1973 - Preliminary IFRT tests completed.

- March 1973 - The diffuser-combustion system was developed to improve the combustor temperature spread factor (TSF), and a "green run" was conducted to determine the TSF prior to the acceptance test.

- April 1973 - IFRT tests completed

3.0 ENGINE DEVELOPMENT

The engine configuration at the start of the Phase II development program is reviewed below. The initial phase of the engine design and development program was reported in AiResearch Final Report PE-8259-R. Improvements incorporated in the engine during Phase II are discussed in 3.2.

3.1 Engine Design at Start of Phase II

The Model XJ401-GA-400 Engine designed for the Harpoon missile propulsion engine program consisted of a single spool turbojet having a four-stage axial compressor and a single-stage axial turbine supported by a pair of angular-contact ball bearings. Compressor discharge air is directed through a diffuser section in the midframe to an inline annular combustor having air-blast-type (vaporizer) fuel nozzles. Airflow is exhausted through a simple conversion nozzle selected on the basis of superior installed performance throughout the prescribed mission. The compressor rotors were scaled by a factor of 0.6144 from the AiResearch Model GTCP660-4 Auxiliary Power Unit (APU) compressor rotor. The steel rotors were machined separately and pinned together to form the compressor assembly. Each rotor was fabricated on a Pantagraph-type milling machine. Altering of the tracing linkage on this machine permitted immediate scaling of the APU compressor to the size required for the Harpoon engine. The compressor stators were designed to utilize existing production strip-stock tack-welded and sealed into separate bolted half-ring assemblies for each of the first three stages. The fourth-stage stator and annular diffuser were designed to form a part of the midsection structural housing. The midframe structure design specified a cast assembly and included a flange to be used for mounting the engine.

A straight-through-flow annular combustion system was selected in order to maintain minimum diameter and achieve compatibility with

the axial compressor. Burner geometry was set by volume considerations for altitude starting and pattern factor. An air-blast fuel-injection system with J-pipe injector elements provided a simple low-pressure fuel system with minimum parts and complexity.

The single-stage axial turbine configuration was selected because its performance is adequate and because engine cost and length were considerations. The aerodynamic design of the single-stage XJ401-GA-400 turbine was made to satisfy performance requirements, envelope restriction, and the low-cost manufacturing concept.

The initial rotating assembly consisted of an integral turbine wheel and shaft, alternator rotor, fuel pump drive gear, spacers, oil slingers, and compressor rotor. The compressor rotor consisted of four machined stages pinned together and a machined aluminum spinner. The group was supported by two 40-mm angular-contact ball bearings lubricated by a wick oil-mist system. Control of the thrust load on the turbine bearing was initially provided by a Belleville spring washer. The compressor bearing thrust was limited by a secondary flow system regulated by labyrinth and piston-ring seals.

The bearing and lubrication system is based on the wick-mist method. The engine was designed to use DuPont Krytox 143AC oil in its lubrication system. The bearings were lubricated by a wick-reservoir system capable of providing adequate lubrication over the specified temperature and altitude range. The reservoirs were designed to be filled during assembly eliminating future engine service requirements. The wicks were made of glass wool and carried bearing lubricating oil from a batten-filled sump to contacting surfaces on slingers at each end of the shaft adjacent to the bearings. The wicks rubbed on the conical surface of the slingers which produced a pumping action and directed the oil flow as a mist with the bearing cooling air to the bearing face. Cooling airflow and the oil mist were designed to be exhausted through strut cavities to atmosphere.

Starting and ignition energies are supplied by a cartridge starter located within the exhaust nozzle and a pyroflare igniter that fired into the combustor.

The pyroflare igniter was selected for simplicity and reliability. An electrical signal to redundant bridgewire circuits initiates an intense, high-density flame from the 62 percent magnesium flare material.

A fluidic fuel control was initially selected for the engine because of its potential ability to withstand high environmental temperatures that would occur at its mounting location. The simplicity of the fluidic control offered a potential for high reliability, low cost, and the necessary control functions throughout the engine operating envelope. The fuel control was comprised of three basic elements--fuel pump, fuel metering unit, and fluidic computer. The fuel pump design specified a floating-vane-type pump rotating at 92 percent of main shaft speed. The fuel flow to the combustor was regulated by the fuel metering unit, which consisted of a constant differential pressure (ΔP) valve and a metering valve. The ΔP valve was designed to maintain a constant fuel pressure across the metering valve spool, thus permitting the control of fuel flow through the positioning of the spool by command and feedback differential pressures generated by the fluidic computer. The fluidic computer scheduled fuel flow based on engine speed and compressor discharge pressure. The engine speed signal was produced by a chopper driven off the main shaft. The chopper was placed on the pump drive shaft. The pressure signal and computer power were obtained from a pressure tap.

A Rice-type alternator was chosen to provide electrical power to the missile. The Rice-type alternator is a brushless, nonrotating-coil synchronous machine. The design adopted for the Harpoon engine produces 3-phase power. The alternator rotor was designed to be mounted directly on the engine shaft, thus fixing the rotor speed at

shaft speed eliminating the requirement for separate bearings, seals, and lubrication. The stator was designed as a conventional 3-phase winding. The field excitation coils were stationary, and the flux was carried to the rotor through two auxiliary air gaps at each end of the rotor. The stator and field coils were cooled by a portion of the secondary flow.

A power conditioning unit was developed during Phase II. It provides for 3.8 kw of dc power from a 3-phase alternator regulated to 29.7 $\pm$0.3 vdc. In addition, the PCU provides a ready signal at a nominal engine speed of 83 percent.

3.2 Phase II Final Design

Besides the normal development activity, refinements were incorporated during the Phase II program. An inlet device was added; shaft stiffening was employed to improve shaft dynamics; a new control system was developed; cartridge starter was modified; the lubricant was changed for cold starting; and the diffuser-combustor system was improved. A cross-section view of the final Model XJ401-GA-400 engine developed in Phase II is shown in Figure 1. A photograph of a disassembled engine prior to final design is shown in Figure 2. Discussions of final designs of the engine are presented in the following paragraphs.

3.2.1 Inlet

The stationary inlet nose cone shown in Figure 3 was developed during Phase II to provide improved airflow to the compressor when operating in the MDAC missile with the distortion produced by the missile inlet. Cooling air for the bearings and alternator enters the engine through the nose cone opening and flows through metering orifices in the main shaft. The temperature sensor visible at the top of Figure 3 has been incorporated in the nose cone to provide a compressor inlet temperature (T_2) signal to the electronic control governor circuit.

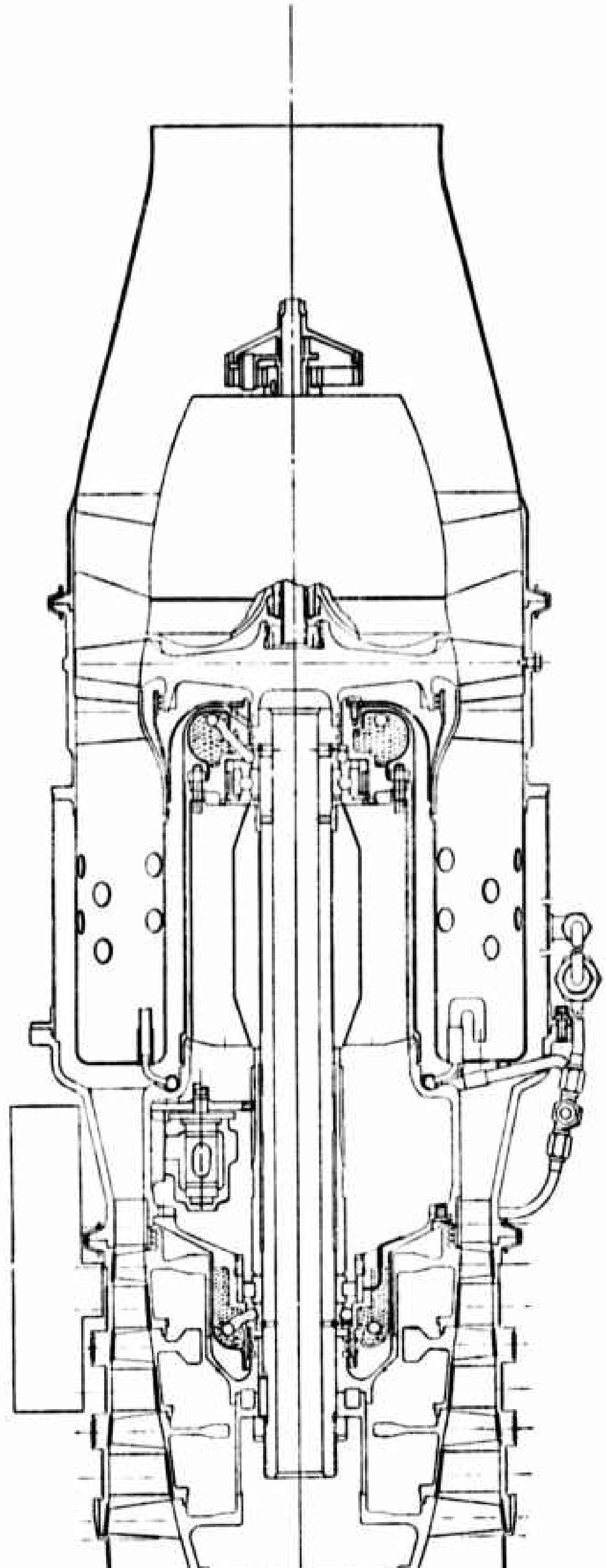


Figure 1. Final Phase II Engine Design.

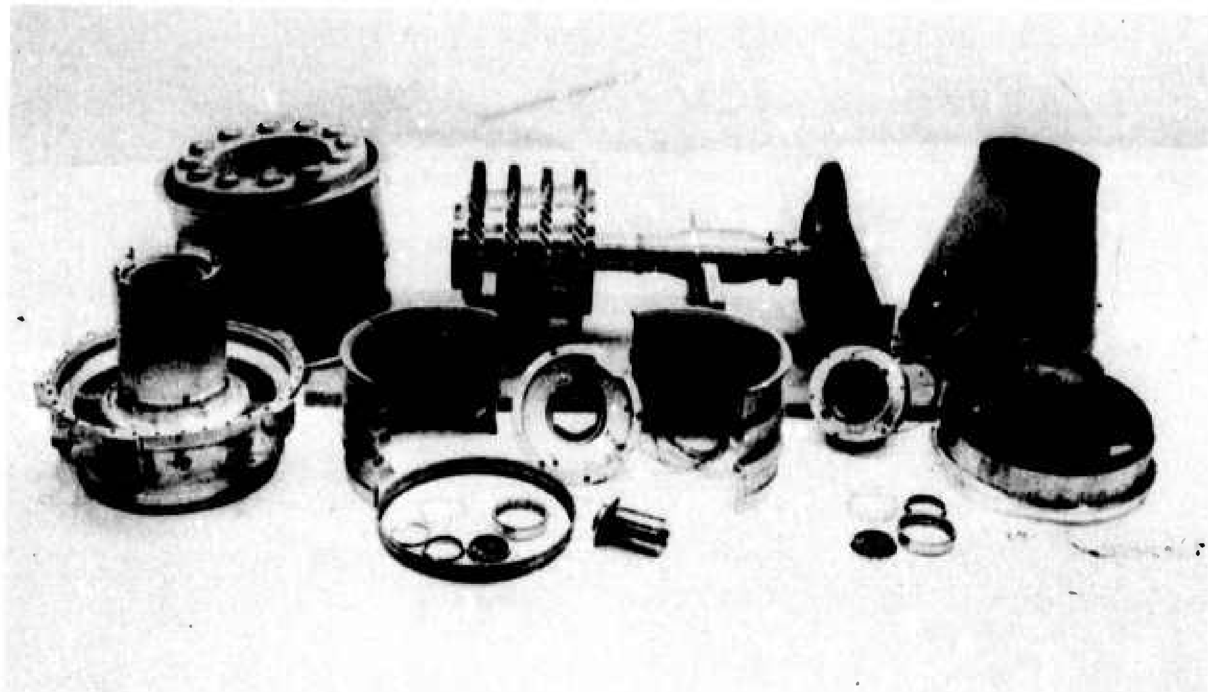


Figure 2. Model XJ401-GA-400 Engine Components
Prior to Final Design.

3.2.2 Compressor

The four-stage axial compressor rotor is cast from 17-4 PH stainless steel with integral blades and support structure. Each stage was piloted and pinned to the succeeding stage early in the Phase II development program. Later, testing in IFRT led to E-Beam welding of all four stages. An abradable material was added to the surfaces between the compressor stages and between the stator stages. The need for abradable material was disclosed in early Phase II development tests. The material was added to protect the hardware and improve clearances. A groove was added in the hub section to accomodate a second piston ring seal to minimize air leakage. An assembled rotor consisting of four cast stages with an integrally cast inlet spinner is shown in Figure 4.

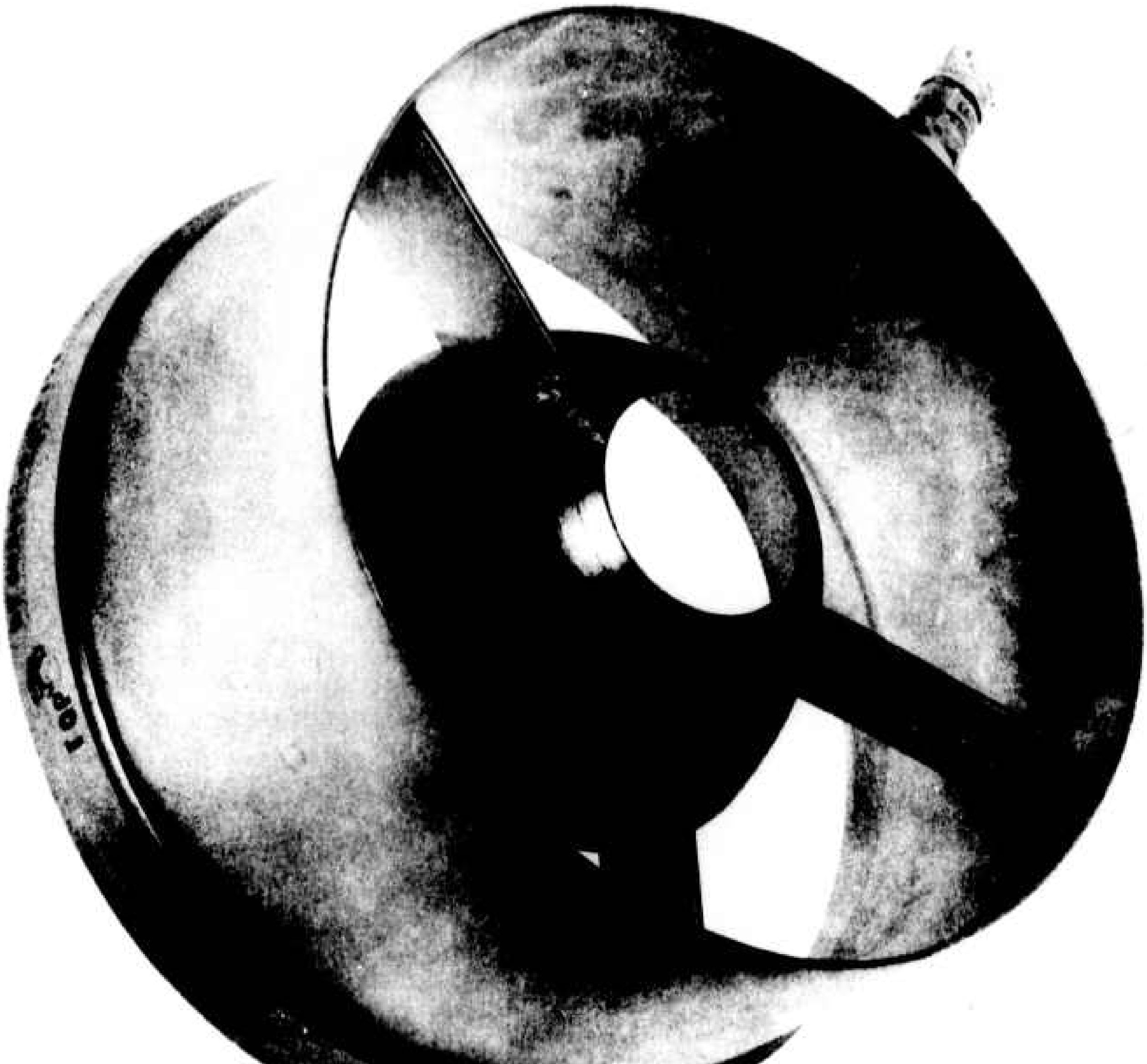


Figure 3. Stationary Inlet Nose Cone with T_2 Sensor.

Figure 4. Cast Compressor Rotor.

The housing for the first three stator stages was machined from low carbon steel tubing and divided into halves. Stator vanes made from 17-4 PH material were welded into holes milled by electrical discharge machining in the housing and sealed in place. The compressor housing is held together with band clamps. V-type band clamps attach the housing to the mid-frame assembly. A view of the the first-three stator stages of the compressor housing is presented in Figure 5. The fourth-stage stator is cast as a single piece and bonded and pinned into the midframe assembly.

3.2.3 Midframe

The midframe in Figures 6 and 7 was the configuration prior to the improvements incorporating trip tubes and poles in the diffuser. The flange shown at the top of the midframe in Figure 6 holds the ignition pyroflare. The midframe was sand cast as a single unit of ductile iron. Provisions for relubrication were incorporated during Phase II by the addition of a 1/16 inch tube routed through the midframe to the rear bearing. The tube can be seen on the left side of the midframe in Figure 6. The midframe was originally designed to house a fluidic fuel control. Modifications required to accomodate the electronic fuel control were minor. The fuel manifold consisting of 12 nozzles brazed into a fuel distribution tube is press fitted and potted into the midframe assembly. The manifold is visible in Figure 7, and the improved midframe is shown in Figure 54.

3.2.4 Combustor

The original combustor design is shown in Figure 8 and the improved combustor is shown in Figure 52. The holes adjacent to the swirlers are the holes into which the fuel feed tubes are inserted during engine assembly. Cooling and dilution holes were punched in the sheet metal prior to forming. The "J" tubes and air swirlers are welded into place and the assembly is then welded to the turbine inlet nozzle. The pressure tap for P_{cd} was relocated from the midframe

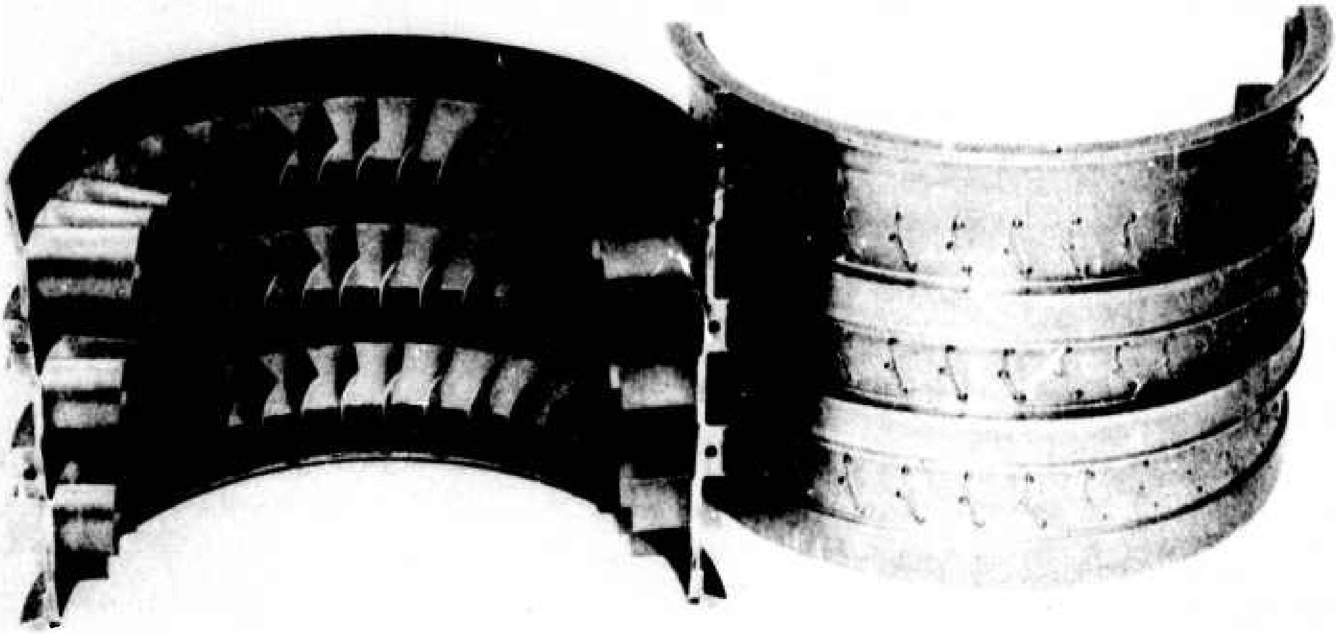


Figure 5. Compressor Stator Assembly.

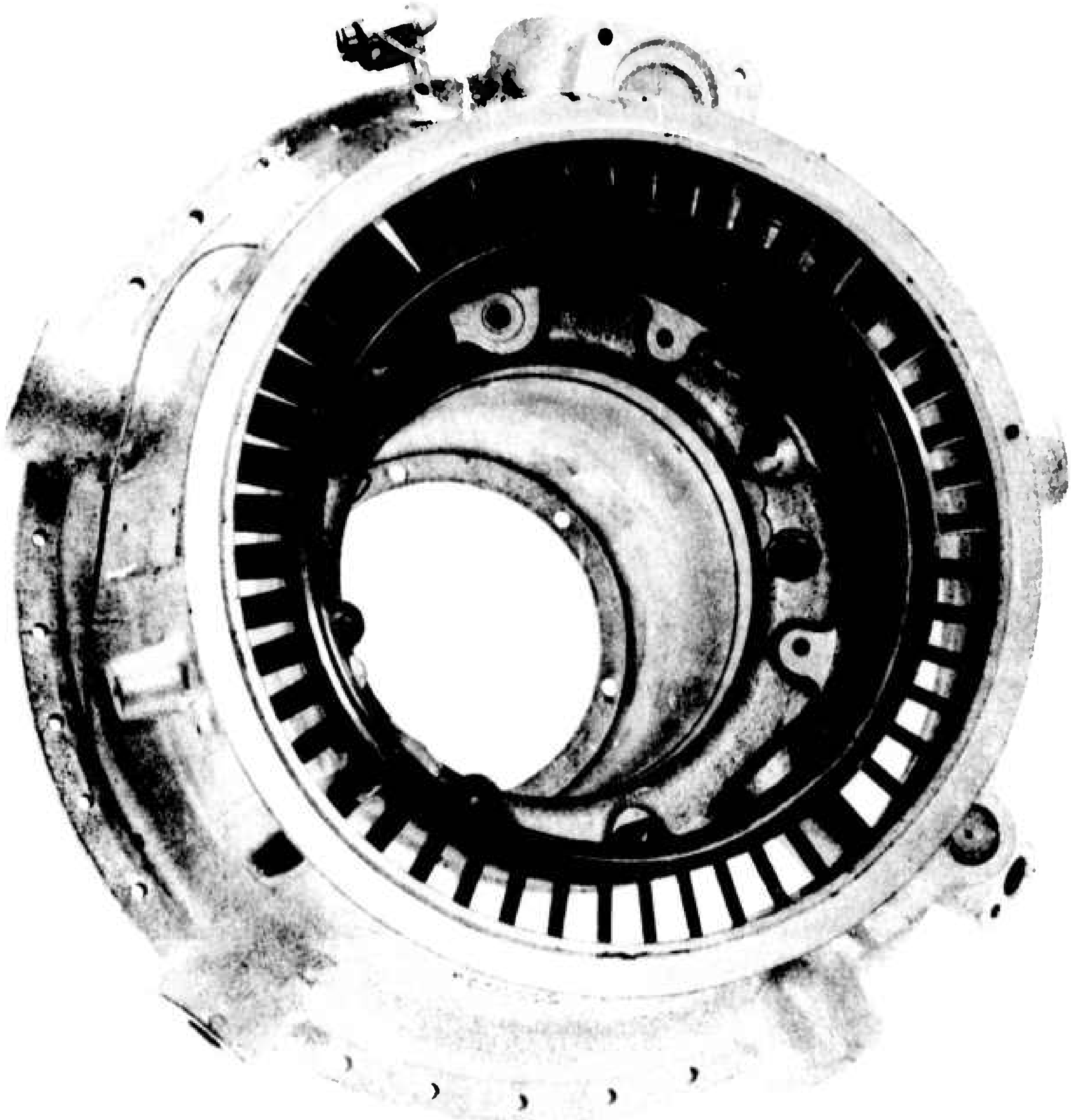


Figure 6. Forward End of Midframe. The Final Design is Shown in Figure 54.

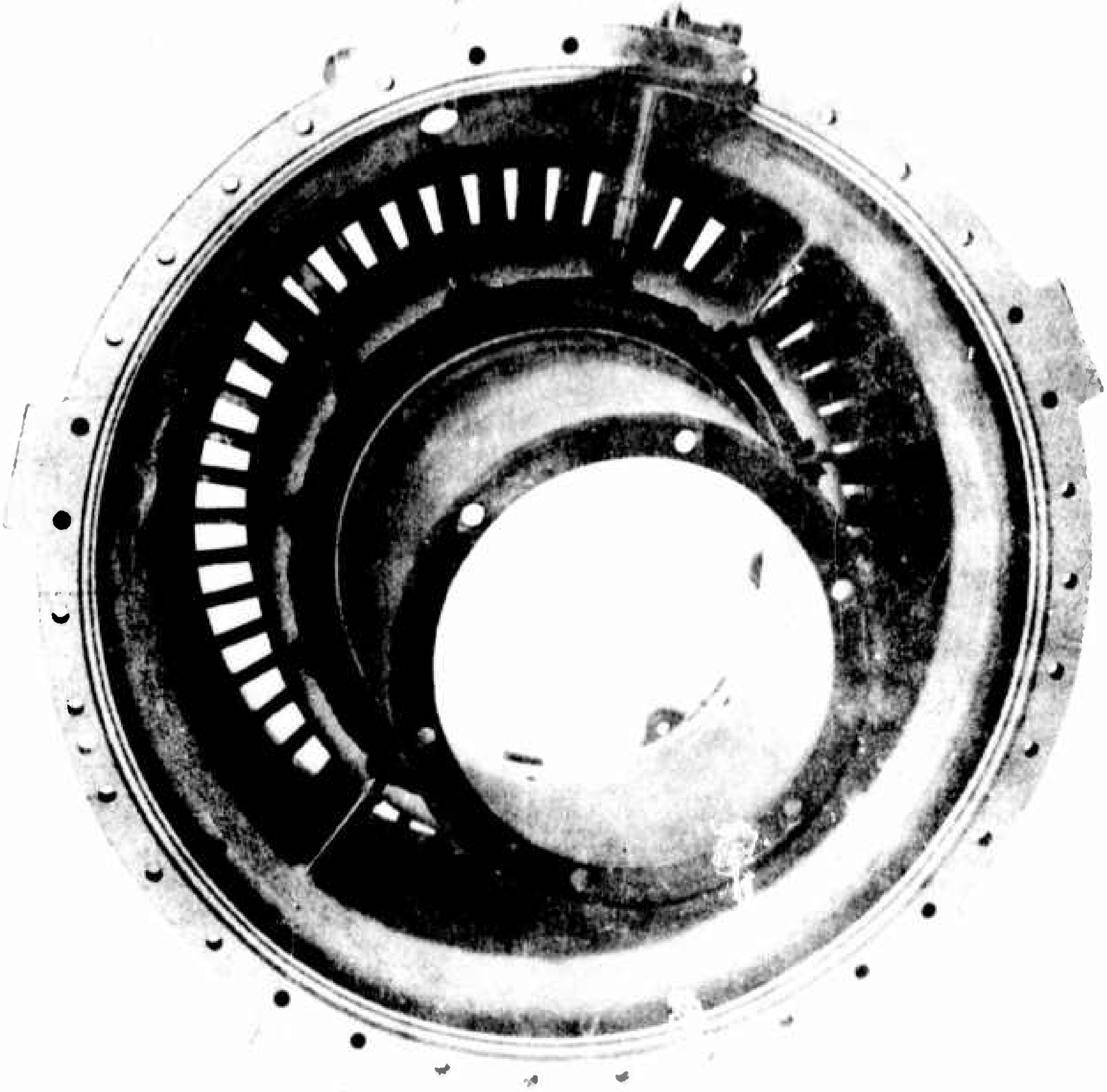


Figure 7. Rear End of Midframe Assembly. The Final Design is Shown in Figure 54.

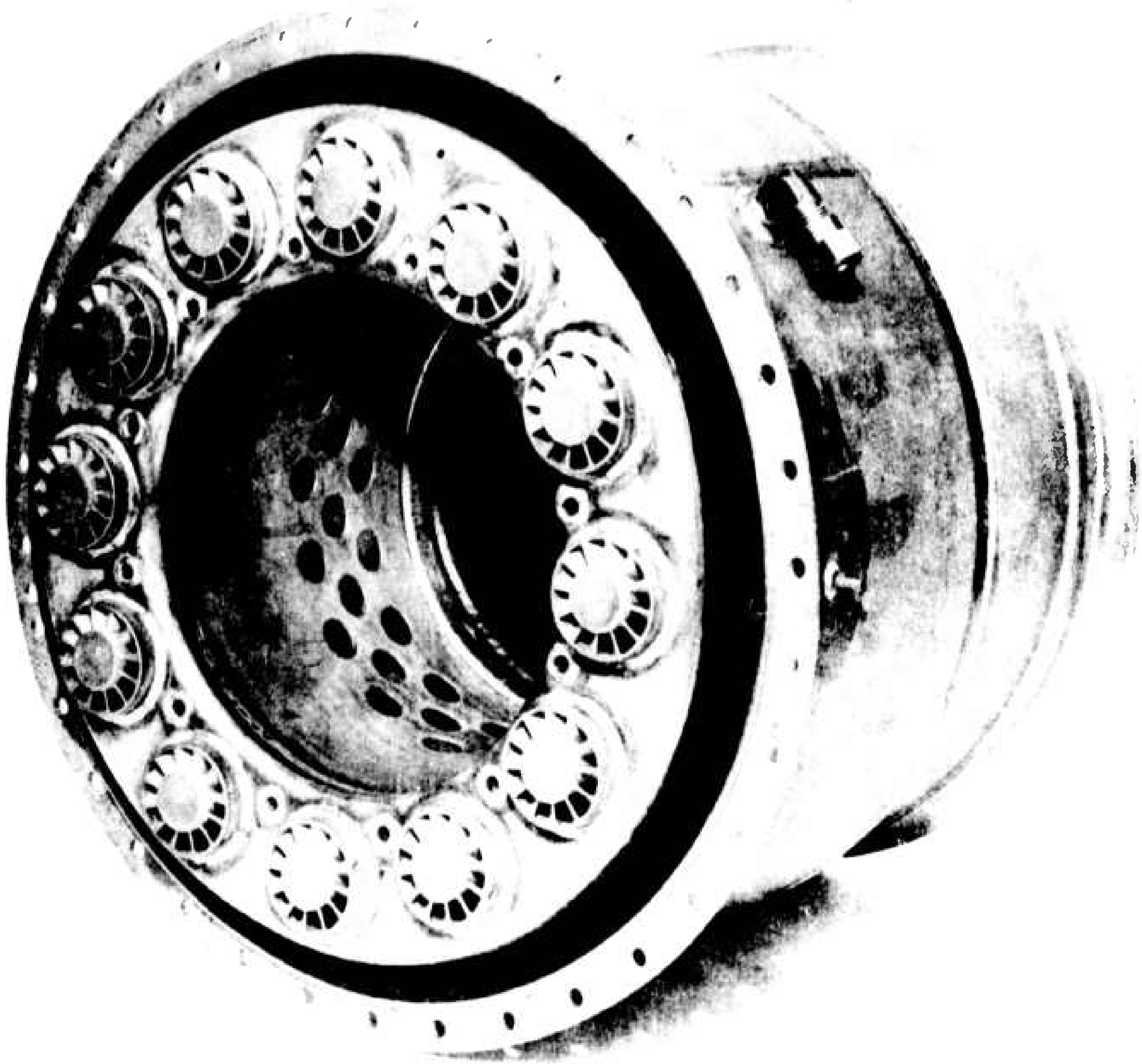


Figure 8. Combustor and Turbine Nozzle Assembly (Forward View). The Improved Combustor is Shown in Figure 52.

to the combustor plenum to provide steady pressure supply air to the control unit.

3.2.5 Turbine

The turbine wheel is cast with integral blades from IN-100. The choice of IN-100 material was based on engine life requirements. The wheel is E-Beam welded to the engine shaft, which is machined from CRES 21-6-9 material to form an integral unit.

The turbine stator vanes and turbine shroud were cast from HS-21 and welded to the combustor. The stator vanes are shown in Figure 9. The turbine wheel and shaft assembly (before cooling improvements) are shown in Figure 10, and the turbine shaft for improved bearing cooling is shown in Figure 49.

3.2.6 Rotating System

Following the June IFRT program, during which bearing problems were encountered, an engine was instrumented so that the motion of the rotating assembly could be recorded. The results (bearing loads and rotor excursions) showed that the third critical speed of the rotating assembly was too close to the operating speed of the engine. In some cases this resulted in radial unbalance loads that exceeded the design capability of the bearings.

To correct this problem, design changes were made to stiffen the rotating assembly, thereby increasing the third criitcal speed. The four-piece gear and spacer assembly that drives the fuel pump and provides shaft stiffness was consolidated into one piece as shown in Figure 11. The outside diameter of this assembly was increased contributing to shaft stiffness. The change to a one-piece assembly reduced the normality errors, providing an improved runout of the rotating assembly. The alternator rotor was changed from a three-piece assembly to a single piece for the same reasons. The one-piece rotor and single piece gear (before cooling improvement to thrust bearing) are shown assembled to the rotating group in Figure 12. The larger cooling holes in the shaft are shown in Figure 49 .

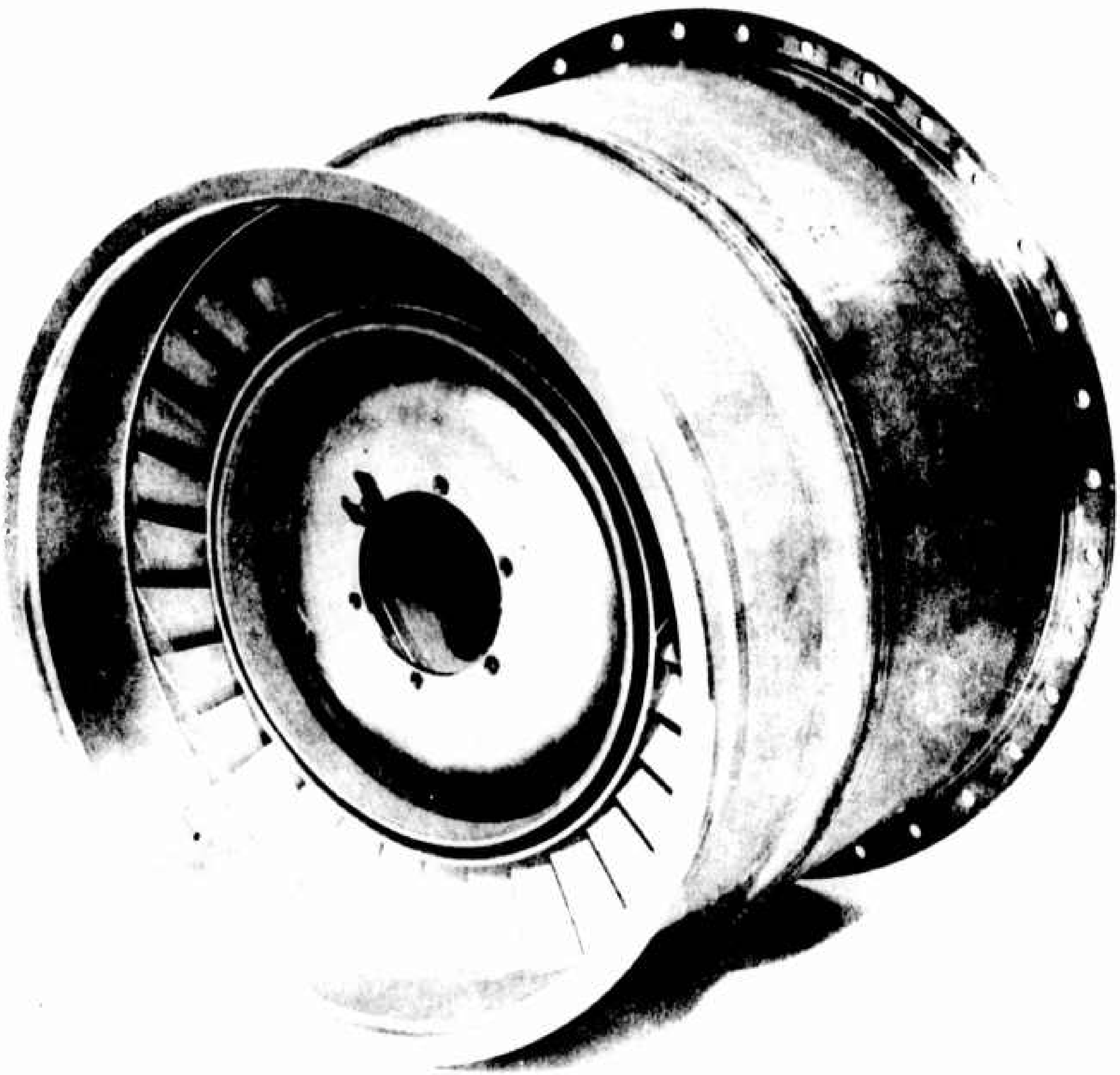


Figure 9. Combustor and Turbine Nozzle Assembly (Aft View). The Improved Combustor is Shown in Figure 52.

Figure 10. Turbine Wheel and Shaft Assembly. The Final Design is Shown in Figure 52.

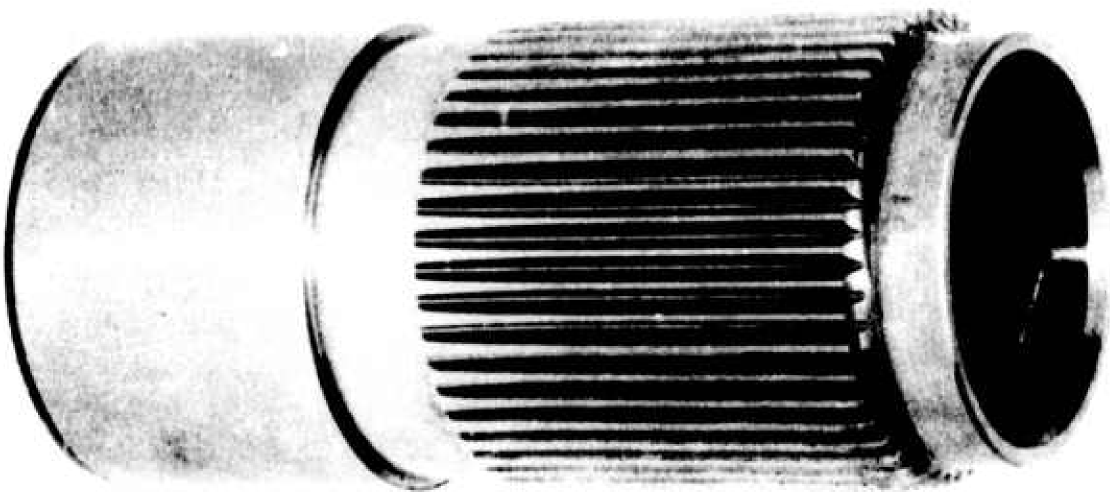


Figure 11. One Piece Fuel Pump Drive Gear; Replaces Three Spacers and Gear.

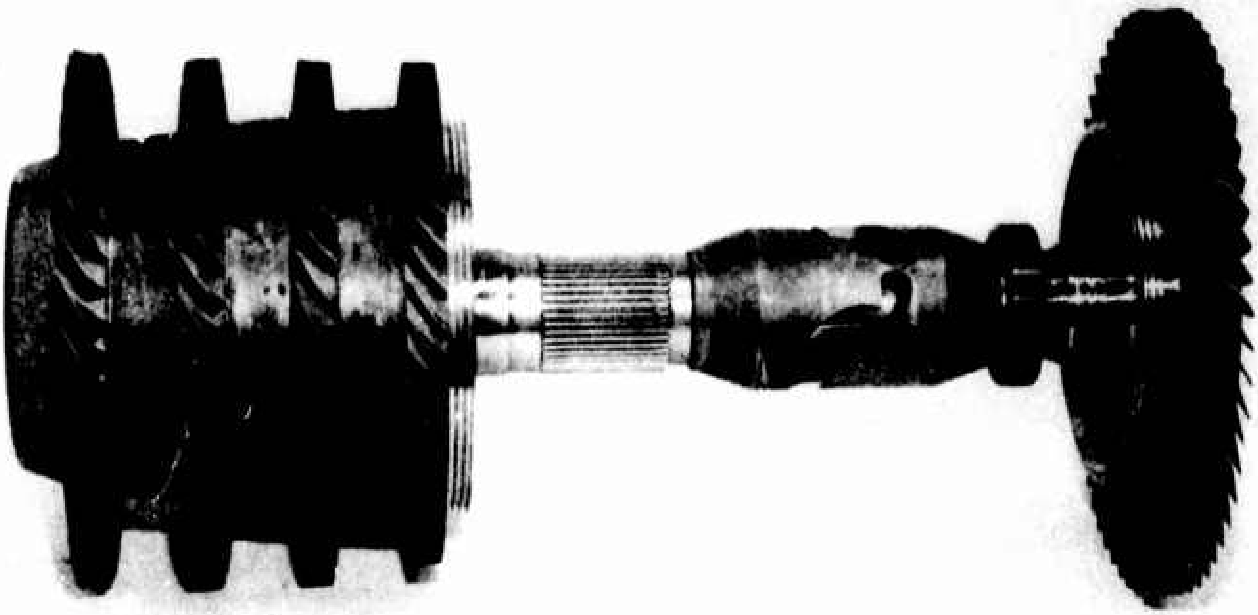


Figure 12. Final Configuration of Rotating Assembly Showing One Piece Gear and One Piece Alternator Rotor. (See Figure 52 for Larger Cooling Holes in the Shaft)

Other improvements related to shaft dynamics included increasing the turbine shaft diameter to provide tighter radial fits at both bearings and other members of the rotating group.

3.2.7 Bearings, Seals and Lubrication

Based upon rig test results, 40-mm-bore-diameter bearings were selected for use on the Phase II engine. The use of the larger-size bearings simplified the design of the engine shaft reducing fabrication costs. Split-inner-ring single row ball bearings were selected initially because they were less sensitive to temperature extremes. However, because of large radial tolerances they permitted excessive unbalanced movement of the rotating assembly which in turn contributes to bearing failures.

As a result of problems encountered during engine development and rig tests, several changes were introduced in the design of the bearing system. Initial problems led to enlargement of the metering orifices in the shaft to provide better airflow across the bearings. In addition, an extra set of holes were added to cool the aft-end of the alternator rotor and the turbine bearing. During the June IFRT, premature bearing failures were encountered. Examination of the failed bearings showed the cause to be excessive radial loads. Further investigations were made to determine the nature of the excessive radial loads. An engine was instrumented so that the radial bearing loads could be measured. Probes were incorporated to permit the motion of the rotating assembly to be recorded. The results (bearing loads and rotor excursions) showed that the third critical speed of the rotating assembly was too close to the operating speed of the engine. In some cases this resulted in radial unbalance loads in excess of the design capability of the ball bearing. Several alternatives to the original design were studied and tested to eliminate the third critical speed problem. Various combinations of ball bearings, roller bearings, hydraulically mounted bearings, one piece gear shafts, and different

alternator rotor configurations were tested. The majority of these tests were conducted on a dynamics rig capable of driving the complete Harpoon engine to 40,000 rpm. The results of these tests are presented in Table I. The configuration used in Engine S/N 3302, Build 2, was selected for the final engine design. Additionally, five 30-minute endurance runs were conducted with engines having roller-ball bearing configurations. Consequently the roller bearing shown in Figure 13 was substituted for the compressor ball bearing used in earlier Phase II engine configurations.

The roller bearing was selected from the AiResearch TSE231 Engine design. Every other roller was removed to allow for proper cooling airflow across the bearings. The roller-ball bearing configuration has performed very well since it was adopted.

The piston ring geometry has been altered from that of the earlier engine. The seals were modified in order to minimize housing bore wear during startup with the cartridge starter. The changes include larger diametral interference, extension of width dimension, increased wall thickness, and the introduction of carbon as a substitute for the steel rings selected initially. The new rings are shown in Figure 14.

Lubrication was provided by a wick system using DuPont Krytox 143AC as the lubricant. The wick system consists of fiber-glass wicks that carry the lubricant from a fiber-glass batting-packed sump to a conical-shaped slinger by capillary action. Due to centrifugal forces caused by shaft rotation, and airflow across the wick, the lubricant is pumped up the slinger and through the bearing. One wick system is used for each bearing. The change to a roller bearing-ball bearing configuration necessitated a change to the slinger length. The new slingers are shown in Figure 15. Further changes were incorporated as described in Section 4.7 due to low temperature difficulties.

TABLE I. SUMMARY OF BACK-TO-BACK RIG TEST RESULTS.

Engine			Configuration	Shaft Excursion at 36,000 rpm, mils
Test No.	Serial No.	Build		
1	3302	1	Ball-ball brgs. Std. alternator one-piece gear shaft (thin)	16
2	3302	1A	Ball-ball brgs. Dummy alternator, thin one-piece gear shaft	4
3	3305	1	Ball-ball brgs. Comp. brg. hyd. mount one-piece gear shaft (thin	6
4	3304	2	Roller-ball brgs. Std. alternator. One-piece gearshaft (thin)	4
5	3305	2	Roller-ball brgs. Hyd. mount compr. brg. Dummy alternator. One-piece gear shaft (thin)	10
6	3302	2	Roller-ball brgs. One-piece alt. Thick gear shaft (constant)	3
7	3302	2A	Roller-ball brgs. Thick sleeve alt. Thick gear shaft (constant OD)	4
8	3307	1	Roller-ball brg. One-piece alt. Externally fed hyd. mount on comp. brg.	5
9	3302	2B	Roller-ball brg. Std. alt., thick gear shaft (constant OD).	5

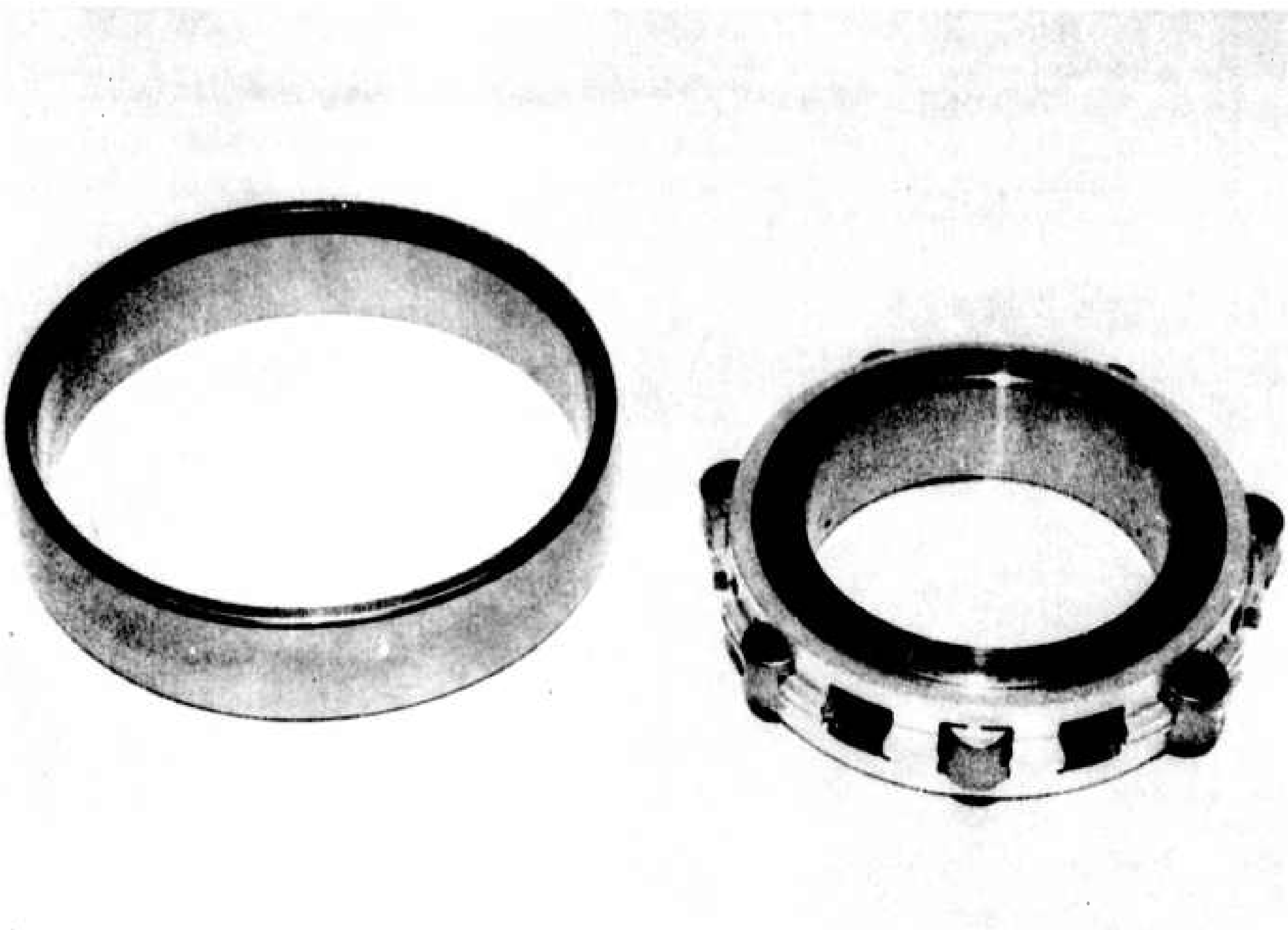


Figure 13. Roller Bearing.

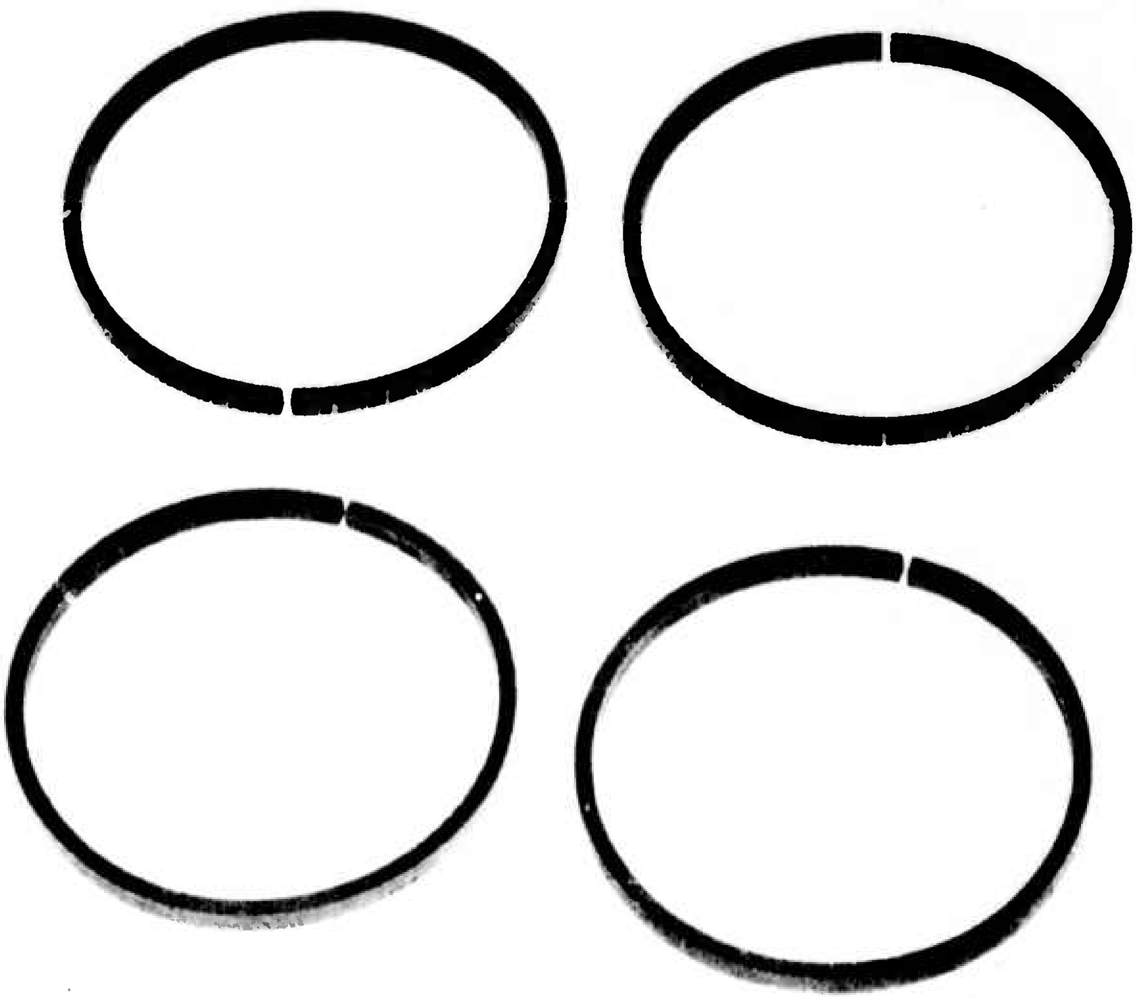


Figure 14. Carbon Piston Ring Seals.

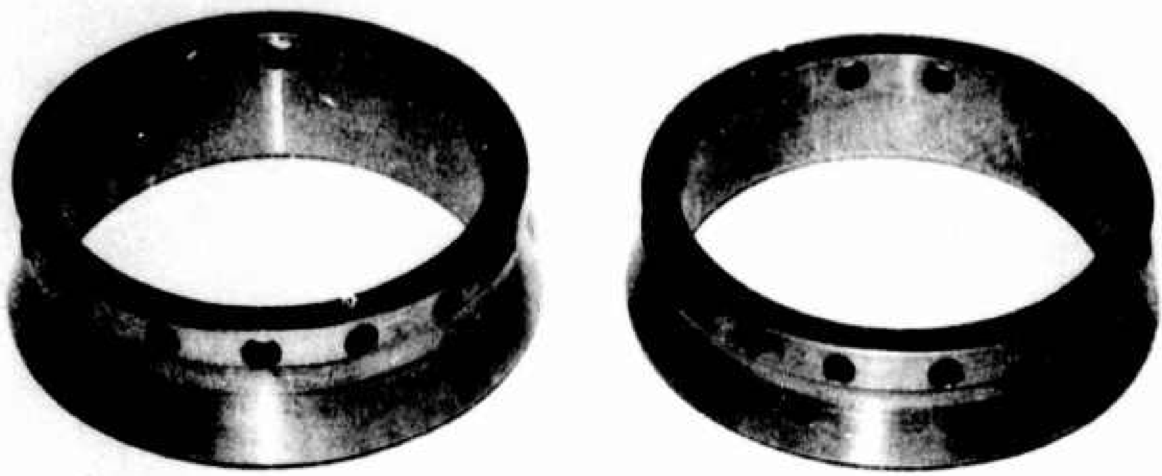


Figure 15. Configuration of Bearing Oil Slingers.
Final Configurations is Shown in Figure 50.

3.2.8 Starting and Ignition

Two types of cartridge starters, geared and ungeared, were developed during Phase II. The geared starter is comprised of a small single stage axial turbine, a planetary gear train, a drive shaft, a clutch, and a solid propellant cartridge. The starter cartridge is ignited by an electrical initiator. Cartridge gases impinge on the starter turbine which is geared to a shaft that engages the engine rotor through the clutch. The starter mechanism and cartridge are housed within the engine exhaust cone.

A starter modification to eliminate the planetary gear train was also developed and tested during Phase II. The concept offerred promising returns in terms of cost savings and weight reduction. However, because of difficulties experienced with this starter at high altitude and low Mach numbers further development work was discontinued. Both starter types are shown in Figure 16.

A zero backlash type clutch has been developed in Phase II to provide more positive engagement of the engine and starter. The decoupler is pinned together as an assembly to ensure zero backlash and provide windmilling capability, and is inserted into the engine with a spline. It decouples with reverse torque as the starter slows down and the engine continues to rotate.

The turbine wheel is accelerated by the cartridge gases and torque is transmitted through the jaws of the decoupler mechanism to accelerate the engine to combustor ignition speed. The starter assists engine acceleration until the cartridge is spent. After cartridge burnout, positive torque is no longer provided by the starter and the aerodynamic drag of the starter turbine plus bearing friction create sufficient reverse torque to cause the decoupler jaws to shear the pin and disengage, thereby decoupling the starter from the engine. The pin is strong enough to withstand the reverse torque produced by

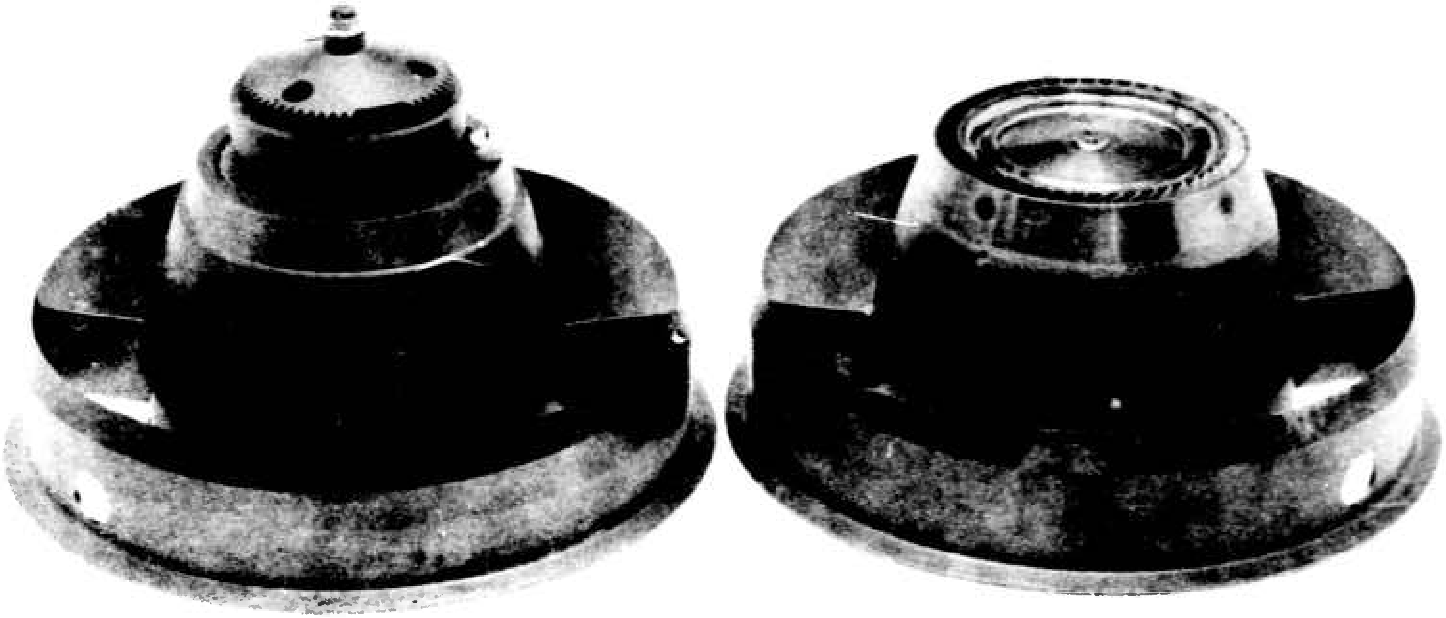


Figure 16. Geared and Ungeared Starters.

engine rotation during a Mach 0.9 inlet ram condition. Figure 17 shows a photograph of a two-jaw decoupler and engagement shaft.

Refinements were made to the starting system to provide consistent altitude cartridge starts at cold temperatures and low Mach numbers. An improved geared starter was developed in Phase II that produces higher assist speeds. The higher assist speeds assure successful altitude starts.

During the Phase II engine development program pyroflares made by two manufacturers were used. The pyroflares were made by Unidynamics Inc. and Holex Inc. Of the two, pyroflares manufactured by Unidynamics were selected because they exhibited better burning characteristics for longer periods than the Holex cartridges. Start tests conducted with the geared starter and Unidynamics pyroflares have consistently demonstrated the ability of the engine to start successfully.

3.2.9 Fuel-Control

During the engine wind-tunnel tests and the June IFRT, difficulties experienced with the set point on the fuel control sometimes caused the engine to operate erratically. Subsequent analyses disclosed several reasons for the inconsistent behavior of the fluidic control system. Chief among these was the high ambient temperature at the fuel control location within the engine. Thermal transients experienced by the maximum-ratio and governor fluidic circuits caused the fuel flow and thrust to fluctuate. Although improved temperature compensation measures were employed, satisfactory governor action was not consistently realized. As a result, the electronic backup control was perfected and incorporated in the final Phase II engine configuration.

The electronic control system provides for automatic control of the engine from initiation of the start sequence through acceleration to maximum speed and power, throughout the engine operating envelope.

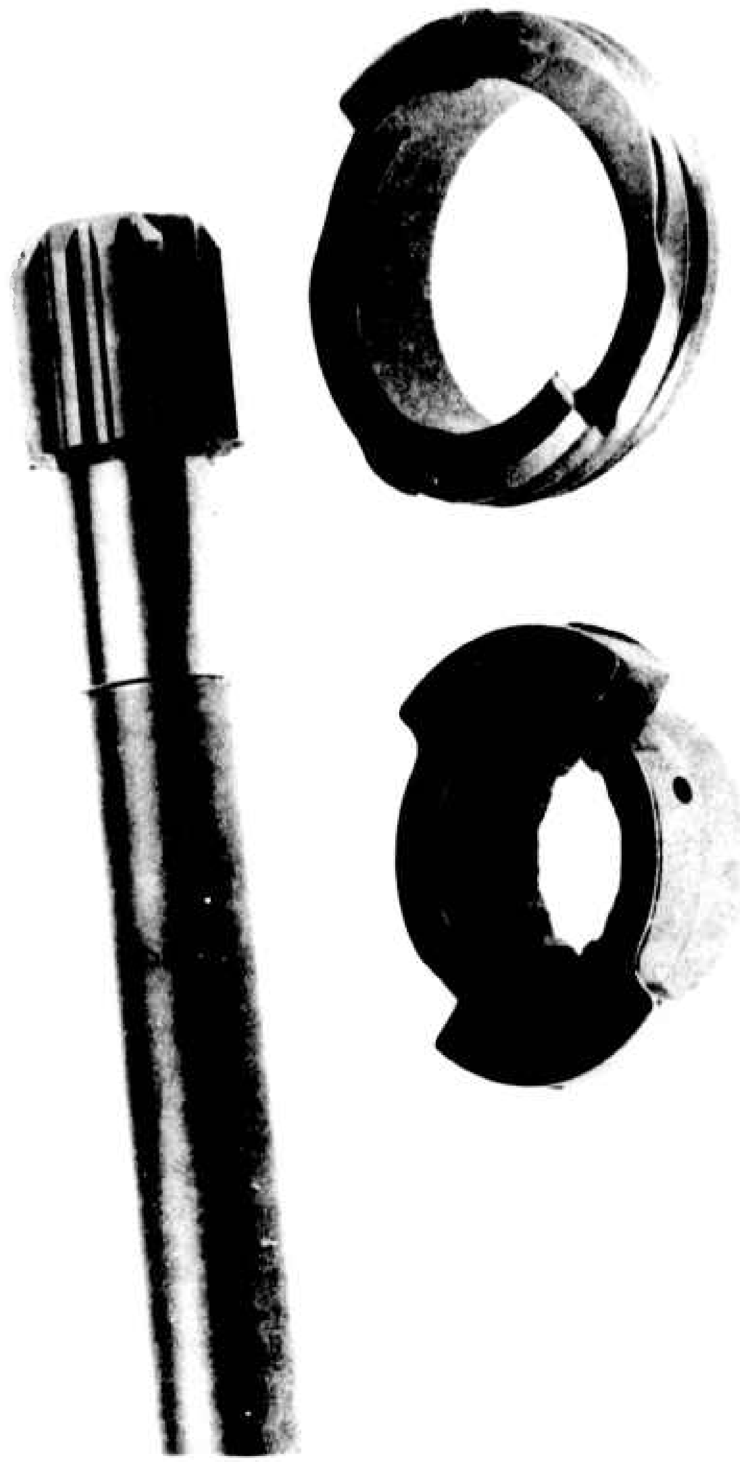


Figure 17. Two-Jaw Decoupler with Engagement Shaft.

The system consists of an electronic computer, a fuel metering assembly, an inlet-total temperature sensing probe, and an electrically operated pressure control valve. All but the inlet temperature probe are shown in Figure 18. The T_2 probe can be seen on Figure 3.

The fuel metering assembly consists of a constant displacement fuel pump, a head-regulating valve, and a fuel-metering bellow actuated valve. A portion of the fuel supplied by the constant displacement pump is bypassed by the head-regulating valve back to the pump inlet, thus maintaining a constant differential pressure across the metering valve. The metering valve is stroked linearly by the sum of the control gauge pressure, P_x, (bellows chamber pressure) and atmospheric pressure acting on the evacuated bellows. Fuel flow is therefore proportional to the absolute value of P_x. The selection of the pneumatic orifices in the circuit results in P_x being proportional to compressor discharge pressure. The net effect of this arrangement is that fuel flow is proportional to compressor discharge pressure. Changing the position of the torque motor flapper changes the value of P_x and results in a change in fuel flow, permitting modulation of fuel flow to the engine. The torque motor flapper is controlled by a signal from the electronic computer which in turn, has inputs of speed and total inlet temperature. The governor set point is a function of total temperature causing operating speed to decrease with decreasing temperature. Engine protection is provided by a maximum fuel schedule.

Another cause of inconsistent fuel control action was found to be fluctuations in compressor discharge pressure (P_{cd}). The P_{cd} probe in the June IFRT engine configuration was a total pressure probe located just aft of the fourth stage stator. The probe faced into the air flowpath and contained a small inline filter. Analysis of the pressure signal supplied by this probe indicated that it was sensitive to small fluctuations in total pressure. In addition, because of its small size, the filter was easily contaminated by trapped particles encountered during normal endurance testing and in turn contributed to

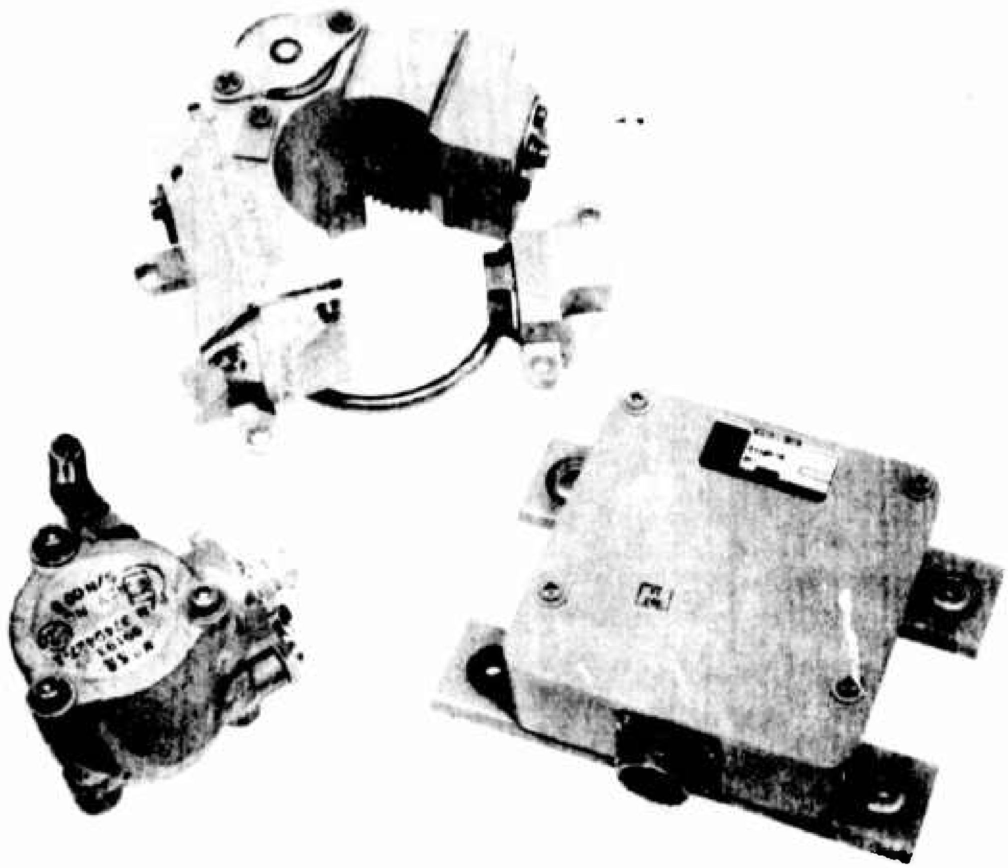


Figure 18. Electromechanical Fuel Control Showing Fuel Metering Section at Top, Electronic Computer at Bottom Right and an Electrically Operated Pressure Control Valve at Bottom Left.

pressure drops in the signal supplied to the control. In order to correct these problems, the P_{cd} probe was changed to a static pressure probe relocated to the combustor plenum. This area is much less subject to pressure fluctuations. In addition, a larger filtration system has been developed which has eliminated the pressure drops experienced in the previous system.

3.2.10 Electrical System

The engine electrical power system is a two-wire ungrounded design. The system provides up to 3.8 kw continuously in a voltage range of 29.4 to 30.0 volts dc throughout the steady-state operating envelope of the engine. This power is generated by an internally mounted alternator described in 3.1 and is rectified by a power conditioning unit (PCU).

The PCU, shown in Figure 19, performs the following functions:

- o Rectification of the alternator output to dc
- o Regulation of the alternator field excitation to control the output voltage at a nominal 29.7 volts dc
- o Sensing of alternator frequency and provision of a "ready" signal at a nominal engine speed of 83 percent.
- o Filtration of rectified dc power to meet specified EMI limits
- o Provides a continuous speed signal to the electronic control
- o Provides dc power to the electronic control

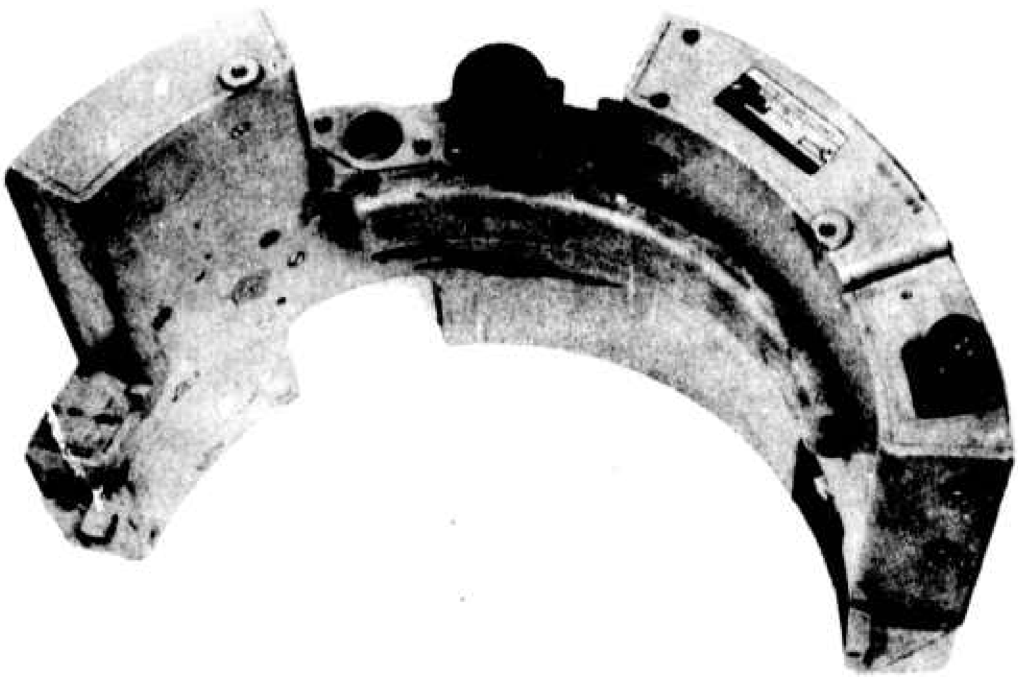


Figure 19. Power Conditioning Unit.

The PCU consists of the following major circuits:

(a) Rectifier and Filter Circuit - The rectifier and filter circuit takes the 3-phase ac power from the alternator, rectifies it by means of a simple 3-phase full-wave diode-rectifier bridge, and filters it with a group of capacitors. The resulting dc power provides the 3.8-kw output and all internal power requirements.

(b) Field Regulator - The field regulator circuit monitors the dc output voltage and controls the dc field current to the alternator in order to regulate the output voltage at 29.7 $\pm$0.3 vdc. The field current is controlled by switching transistors that pulse the field with a dc voltage. The dc field voltage has a variable duty cycle, depending upon the dc load.

The field regulator circuit also monitors the average dc current to the field and limits it at 17 amperes in order to protect the alternator against an overload. This function is performed by a current-sensing amplifier that biases the field-regulation circuit to reduce the output voltage as the overload increases.

Finally, the field regulator circuit provides a reference voltage for the frequency sensor circuit and for its internal use.

(c) Frequency Sensor - The frequency sensor circuit monitors the frequencies of the alternator voltage, which is proportional to engine speed, and provides a "ready" signal output when the engine speed reaches 83 percent.

3.2.11 Exhaust System

The convergent nozzle developed during the Phase II program was required by MDAC and replaced the plug nozzle used on the demonstrator engine. The convergent nozzle is shown in Figure 20. The design was governed by the following constraints:

- Inlet hub radius and slope
- Inlet tip radius and slope
- Inlet Mach number
- Exhaust system length
- Cartridge starter volume
- External diametral limitations

In addition to the design of the tailcone, the contour of the cartridge starter housing and support struts was accomplished as part of the nozzle improvement.

3.2.12 Mountings and Fittings

Five engine mounts have been provided on the midframe casting to interface with the missile airframe. The mounts may be utilized to support the engine on ground equipment.

The engine air inlet provides for a slip-joint connection to the missile. Since there is no requirement or provision for mechanical fastening of the inlet duct to the engine inlet, a pliable seal on the missile ducting will allow for adjustments of minor misalignments. Clearances required for engine expansion and alignment are consistent with engine/missile mount provisions. Connections between the engine and airframe are listed on Table II.

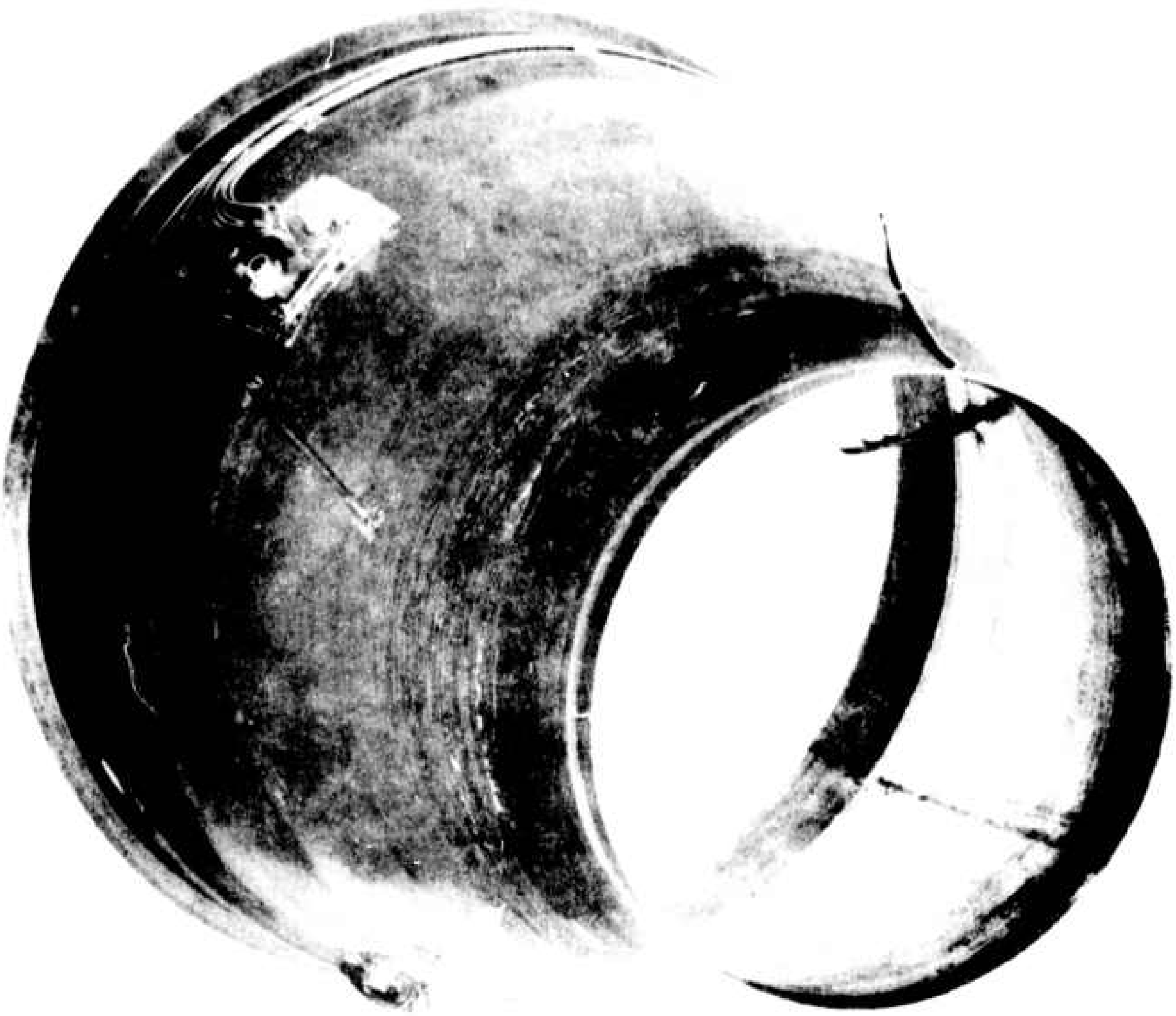


Figure 20. Exhaust Nozzle.

TABLE II. CUSTOMER CONNECTIONS.

Type of Connection	Location	Size and Type
Electrical Input (Start-Ignition)	Top, right	M81511/01FB02P1 per MIL-C-81511
Electrical Output	Top, left	M81511/01EF03P1 per MIL-C-81511
Fuel Inlet	Top, just forward of Engine Mount M2	0.737-inch-diameter port
Pressure-Regulated Air	Top, left	0.423-inch-diameter port
Engine Air Inlet	Front of engine	9-inch-diameter slip fit
Engine Mount	Circumference of midframe	0.5-inch-diameter pin bore
Vibration Pickup Mount	Right side of mid-frame	0.190-inch 10-32 UNJF-3B threaded port

3.2.13 Performance

The engine rating at sea-level 90°F ambient-temperature and 0.85 Mach conditions is 600 pounds of net thrust plus an electrical output of 3.8 kw dc. Rated performance is summarized in Tables III and IV. Thermodynamic and mechanical limits based on the most critical engine tolerances are:

- Maximum compressor inlet total temperature:

194°F (90°C) to 215°F (102°C)	for 1 minute maximum
194°F (90°C)	continuous

- Exhaust gas temperature:

Starting, 3-second limit,	above 2000°F (1093°C) to 2200°F (1240°C)
Transient operation, 3-second limit,	above 1582°F (861°C) to 2000°F (1093°C)

- Maximum allowable rotor speed:

  Up to 37,060 rpm, continuous.

  Above 37,060 rpm to below 38,000 rpm, 10 seconds.

  Above 38,000 rpm to below 39,600 rpm, 3 seconds.

- Electrical load extraction, maximum: 3.8 kw

TABLE III. PERFORMANCE RATING AT STANDARD SEA-LEVEL CONDITIONS.

Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	Specific Fuel Consumption lb/hr/lb of Thrust (Max)	Measured Gas Temperature (Max)		Engine Airflow Pounds Per Second ±3.0%	Electrical Output kw
					°F	°C		
Maximum	Zero	570	35,212	1.267	1500	816	9.5	Zero

TABLE IV. PERFORMANCE RATING AT SEA-LEVEL ALTITUDE, 90°F AMBIENT CONDITION.

	Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	Specific Fuel Consumption lb/hr/lb of Thrust (Max)	Measured Gas Temperature (Max)		Engine Airflow Pounds Per Second ±3.0%	Electrical Output kw
						°F	°C		
a	Maximum	0.85	599	37,060	1.679	1579	859	13.5	Zero
b	Maximum	0.85	600	37,012	1.687	1582	861	13.5	3.8

4.0 TEST RESULTS

4.1 Wind-Tunnel Tests

During the period from April 5 to May 10, 1972, three series of tests were conducted with the Model XJ401-GA-400 Engine installed in the McDonnell-Douglas ETB Harpoon Missile in the 8 x 6 wind tunnel test facility at the NASA-Lewis Research Center, Cleveland, Ohio. The objective of these tests, as defined in MDAC Report PTR-68, was to evaluate the starting and operating characteristics of the engine in the basic airframe over the expected range of flight Mach numbers and missile attitudes. Of particular interest were such features as surge-free starting and operation, start time, mechanical integrity, and installed performance.

- The first series of tests was performed during the period from April 5 to April 14 with use of Engines S/N 3304 and 3305.

- The second series, conducted from April 26 to May 4, was run on the same engines with modifications to the turbine stator and exhaust nozzle areas, and ultimately to the compressor inlet configuration.

- The third series, run on May 8, 9, and 10 at the request of NASC, employed the inlet strut assembly with the basic engine having been restored to the original configuration.

In the latter two series, surge-free starting and operation of the engines were obtained with utilization of the inlet device over the entire range of Mach numbers and pitch/roll angles tested.

4.2 June 1972 IFRT Results

4.2.1 Test Requirements

Initial flight rating tests were first conducted on the XJ401-GA-400 Turbojet Engine between 21 April and 15 June 1972. The tests were conducted to demonstrate the ability of the engine to meet model specification requirements applicable to starting, operation, performance and endurance. Test categories and conditions to which the IFRT was addressed were defined by NASC and included the tests listed in Table V. Each test was scheduled for completion on a separate engine. Each engine was required to complete a minimum of 16 minutes of continuous operation while engine thrust and temperature were held at maximum. Additionally, it was specified that each engine continue to operate at maximum thrust for the test condition until failure occurred or 30 minutes of engine operation had been accumulated.

TABLE V. JUNE IFRT REQUIREMENTS.

Test Procedure	SC-8029 Spec Requirement	Test Title
QT-8079-R1	4.3.14	Altitude Start and Sea-Level Endurance
QT-8079-R2	4.3.6	Inlet Air Pressure Variation and Endurance
QT-8079-R3	4.3.2.2	High Temperature Start and Sea-Level Endurance
QT-8079-R4	4.3.2.1	Low Temperature Start and Sea-Level Endurance
QT-8079-R5	4.3.11	Handling and Maneuvering Loads and Sea-Level Endurance
QT-8079-R6	4.3.4	Vibration and Sea-Level Endurance

4.2.2 Test Results

The June 1972 IFRT program was scheduled for completion within an allotted time-frame. The results of those tests conducted during the specified test period are listed in Table VI. The tests confirmed that the engine will provide the following desirable features:

- Component life--specifically, hot section life
- Starter reliability
- Fuel pump durability
- Electrical system output and durability
- Engine thrust
- Engine fuel consumption
- Start times
- High-Mach-number operation
- Operating with inlet distortion
- Freedom from vibration resonances
- Withstanding high-temperature soak

Problem areas encountered during the June IFRT that required further improvements in engine design were:

(a) Bearing Failures - Premature bearing failures were experienced during some tests.

(b) Fuel-Control Malfunctions - Erratic fuel control action was noted in IFRT and wind-tunnel tests.

(c) Inconsistent Altitude Starts - The engine did not exhibit consistent starting characteristics at 20,000 feet altitude.

TABLE VI. JUNE 1972 IFRT RESULTS.

Test Title	Starting Mach Number	Para. of SC-8029	Test Procedure	Date Completed	Engine Serial No./ Build No.	Test Report	Endurance Time Min.
Vibration Survey and Sea-Level Endurance	--	4.3.4	QT-8079-R6	4-22-72	3307/2	PE-8345-R1	25:20
Altitude Start and Sea-Level Endurance	0.60	4.3.14	QT-8079-R1	5-22-72	3309/3	PE-8345-R2	30:00
High Temperature Start and Sea-Level Endurance	0.38	4.3.2.2	QT-8079-R3	5-24-72	3311/1	PE-8345-R	5:12
Inlet Air Pressure Variation and Endurance	0.90	4.3.6	QT-8079-R2	5-29-72	3308/6	PE-8345-R	10:56
Altitude Start and Sea-Level Endurance	0.38	4.3.14	QT-8079-R1	6-1-72	3309R/5	PE-8345-R	5:08
Sea-Level Endurance	--	4.3.1	SC-8029	6-6-72	3311R/2	PE-8345-R	23:32
High Temperature Start and Sea-Level Endurance	0.85	4.3.2.2	QT-8079-R3	6-14-72	3310/6	PE-8345-R	4:49
Altitude Start and Sea-Level Endurance	0.60	4.3.14	QT-8079-R1	6-15-72	3311RR/1	PE-8345-R	26:19
Sea-Level Endurance	0.75	4.3.1	SC-8029	6-15-72	3309RR/1	PE-8345-R3	32:30

4.2.2.1 <u>Starts</u>

During the IFRT, cartridge starts were made at the conditions summarized in Table VII. All starts were performed with the use of a gearless starter.

4.2.2.2 <u>Operating</u>

The electrical system performed excellently throughout the tests. The alternator and power conditioning unit (PCU) consistently produced rated power output at the required voltage level. The one problem experienced with the system when the PCU ready signal failed on Engine S/N 3309RR was traced to a faulty solder joint. That problem was easily corrected.

Engine operation following installation of the 10-percent circumferential distortion-generating screen was normal. Corrected engine performance consistently matched performance parameters predicted by an analytical model. No evidence of compressor surge was observed at any time during the operational testing.

The vibration survey indicated that no vibration resonances existed during normal engine operation. Vibration levels were nearly constant and within model specification requirements. Vibration did not increase as engine operating time increased. Post-test analyses of the vibration frequencies recorded during the test showed the excitation sources to be bearing ball rotation, shaft unbalance, and alternator pole passage.

4.2.2.3 <u>Performance</u>

Engine performance monitored during the acceptance tests is summarized in Table VIII. The test data shows that the engines developed positive performance margins for thrust or TSFC.

TABLE VII. CARTRIDGE STARTS.

	Pressure Altitude Ft	Simulated Mach No.	Inlet Total Temperature °F	Start Time Sec.	Spec Start Time Sec.
Acceptance	B.L.*	0.85	169	6.6**	8
Altitude Start	20,000	0.60	21	12.5	18
Inlet Air Pressure Variation	B.L.*	0.90	173	5.2	8
High Temperature Start	B.L.*	0.85	135	7.3	8
Sea-Level Endurance	B.L.*	0.75	170	6.3	8

*B.L. = Phoenix ambient pressure.
**Average of six acceptance test starts.

TABLE VIII. ACCEPTANCE TEST PERFORMANCE.

IFRT Test	Engine Serial No.	Net thrust, lb.			TSFC, lb/hr/lb		
		Spec.	Corr.	Percent Margin*	Spec.	Corr.	Percent Margin*
Vibration Survey	3307	600.0	637.6	+6.3	1.687	1.636	+3.0
Altitude Start (0.6M)	3309		651.2	+8.5		1.569	+7.0
High Temperature Start (0.38M)	3311		630.0	+5.0		1.582	+6.2
Inlet Air Pressure Variation	3308		620.0	+3.3		1.648	+2.3
Altitude Start (0.38M)	3309R		596.9	-0.5		1.649	+2.3
Sea-Level Endurance	3311R		612.0	+2.0		1.601	+5.1
High Temperature Start (0.85M)	3310		599.0	-0.2		1.691	-0.2
Altitude Start (0.6M)	3311RR		608.0	+1.3		1.671	+0.9
Sea-Level Endurance	3309RR		598.0	-0.3		1.662	+1.5

*Percent margin relative to Model Specification requirements.

NOTES:
1. Performance was attained with 3.8 kw electrical load.
2. Inlet strut assembly was on all engines, except Serial No. 3307.
3. The data is corrected to sea-level 0.85 simulated Mach number, 169°F inlet total temperature conditions.

Engine S/N 3311R operated within 3 pounds of thrust and 0.002 lb/hr/lb of specified TSFC throughout the 23:32 minutes of its sea-level endurance test. Engine Serial No. 3311RR operated within 3 pounds of thrust and 0.010 lb/hr/lb of TSFC during the 26:19 minutes of its sea-level endurance run. The performance of Engine Serial No. 3309RR was actually higher at the end of the 30-minute endurance run than at the beginning because of a slight increase in fuel flow.

Engine performance at the off-design-point conditions of the IFRT occurred as predicted by the analytical model confirming the estimated performance contained in the model specification.

4.2.2.4 Endurance

Five of the engines subjected to initial flight rating tests exceeded 16 minutes of endurance running (Serial Nos. 3307, 3309, 3311R, 3311RR and 3309RR). Two engines completed 30 minutes of operation.

- Engine S/N 3307 shut down after 25:20 minutes of operation because of a compressor stator-vane weld failure. In order to prevent further failures, all compressor stator welds were reinspected and abradable shrouds added to make the engine rub-tolerant.

- Engine S/N 3311R was shut down after 23:32 minutes of operation. A failure analysis conducted after the test indicates that the fracture or relaxation of one of the turbine-end piston-ring seals caused overtemperature and resultant bearing failure. The test demonstrated the validity of the compressor-imbalance fixes, since the compressor bearing was in good condition after the test and showed that a correct thrust-to-radial load ratio had been obtained.

- Engine S/N 3309 completed the 30:00-minute endurance run in good condition except for the damage resulting from four failed combustor J-tubes and combustor wall buckling. The J-tubes failed because of improper tolerances between the tubes and the reinforcing sleeves. The combustor wall material was subsequently changed from 0.032-inch-thick CRES 347 to 0.050-inch-thick HS-25 alloy.

- Engine S/N 3311RR completed 26:19 minutes of operation in good condition except for damage resulting from failure of both bearings.

- Engine Serial No. 3309RR was in excellent condition at the end of a 32.5-minute endurance run in which performance goals, turbine discharge total temperature, and endurance were achieved.

4.3 Captive Flight Tests

Captive flight tests of the Model XJ401-GA-400 Engine assembled in the Harpoon missile were conducted on a P-3A aircraft at the Naval Missile Center, Point Mugu, California. The tests were conducted on June 15 and 16, 1972 at the flight conditions listed below.

2,500 feet altitude, Mach 0.38
15,000 feet altitude, Mach 0.38
1,500 feet altitude, Mach 0.53
20,000 feet altitude, Mach 0.57
20,000 feet altitude, Mach 0.38

Good starts were achieved at the lower altitudes; however, insufficient gearless starter assist speeds did not permit lightoff or

engine acceleration during the tests conducted at the higher altitudes. This was corrected by the development of the improved geared starter discussed in 3.2.8.

4.4 Endurance Tests

Significant development tests were conducted from September 8 through December 4, 1972. These tests were 30 minute endurance tests conducted on 6 engine builds to evaluate the capability of the ball/roller bearing combination. The engine configurations, parameters measured, and the condition of the bearings after teardown inspection, are shown in Table IX.

4.5 Fuel Control Component Tests

Vibration and EMI tests were conducted as requested by NASC on the Harpoon Engine Electronic Speed Control, Part 306100-1-1.

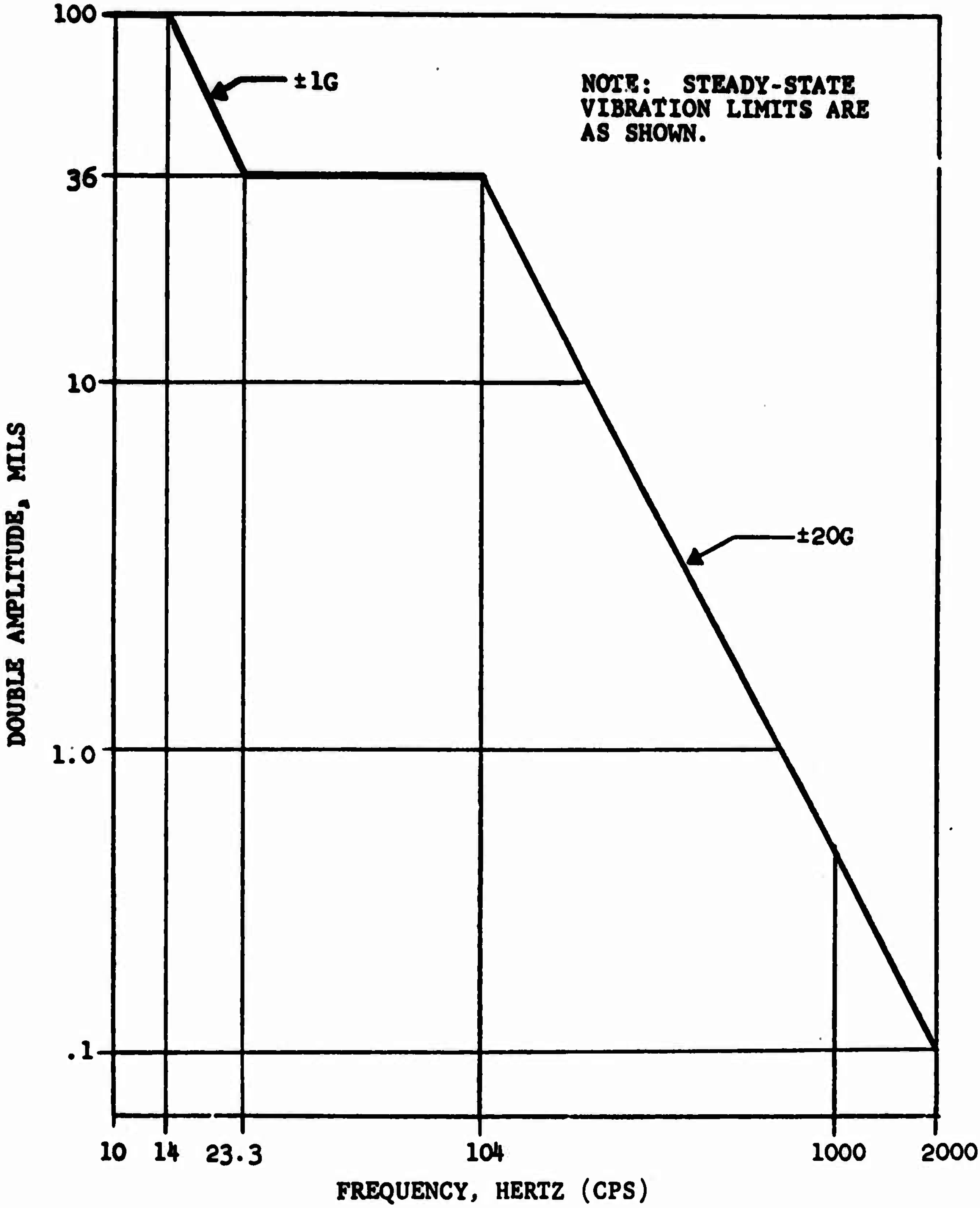
4.5.1 Vibration

Vibration tests were conducted on the electronic speed control on 13 December 1972. The unit was subjected to the test limits defined on Figure 21. Power was supplied to the unit throughout the test. The output of the unit was monitored continuously. No failures or changes in governor set point occurred. Total vibration time accrued on the unit was 23.3 minutes. A functional check completed after the test showed that unit operation was unchanged.

Vibration axes are identified in Figure 22. Test results are presented in Figures 23 through 31.

TABLE IX. ENDURANCE TESTS

Engine S/N	Test Date	P_{CD} PSIG	Alternator Configuration	Gearshaft Configuration	Run Time Minutes	Bearing S/N and Condition After Test: Ball (Steady St. Temp. °F)	Bearing S/N and Condition After Test: Roller (Steady St. Temp. °F)
3304 Bld. 2A	9-11-72	70	Old Standard Four-Piece Rotor	Thin One-Piece	32	S/N 288 Wide paths and skid marks from insufficient thrust (560°F)	S/N 2862 Rollers and paths very good. (400°F)
3305 Bld. 2	9-13-72	72	Dummy	Thin One-Piece	30	S/N 269 Excellent load ratio. Balls good. Thrust both fore and aft. (540°F)	S/N 2352 Excellent (400°F)
3307 Bld. 2	9-20-72	72	One-Piece Rotor	One-Piece Increased Stiffness	31	S/N 303 Thrust mostly aft. Good paths. (550°F)	S/N 2368 Rollers skidded and end loaded. (365°F)
3302 Bld. 2C	9-23-72	72	Old Standard Four-Piece Rotor	One-Piece Increased Stiffness	28	S/N 313 Inadequate lubricant. High unbalance. Skid at split. (540°F)	S/N 2356 Excellent (330°F)
3304 Bld. 3	9-26-72	--	Old Standard Four-Piece Rotor	One-Piece Increased Stiffness	31	S/N 301 Very wide paths. Skid marks. (510°F)	S/N 2358 Rollers skidded and end loaded. (460°F)
3301 Bld. 1	12-4-72	74	One-Piece Rotor	One-Piece Increased Stiffness	4.3 ATP 30 IFRT	S/N 2-278 Heavy aft thrust load. Skidding at split. (660°F)	S/N 5926 Excellent (360°F)



PREPARED	LLC	7-67	VIBRATION LIMITS AT MOUNTING FLANGE	A88937
WRITTEN	JFCW	7-67		
	WBm	7-67		
APPROVED	MK.	7-67	AiResearch Manufacturing Company of Arizona	Figure 21

FORM P708A-1

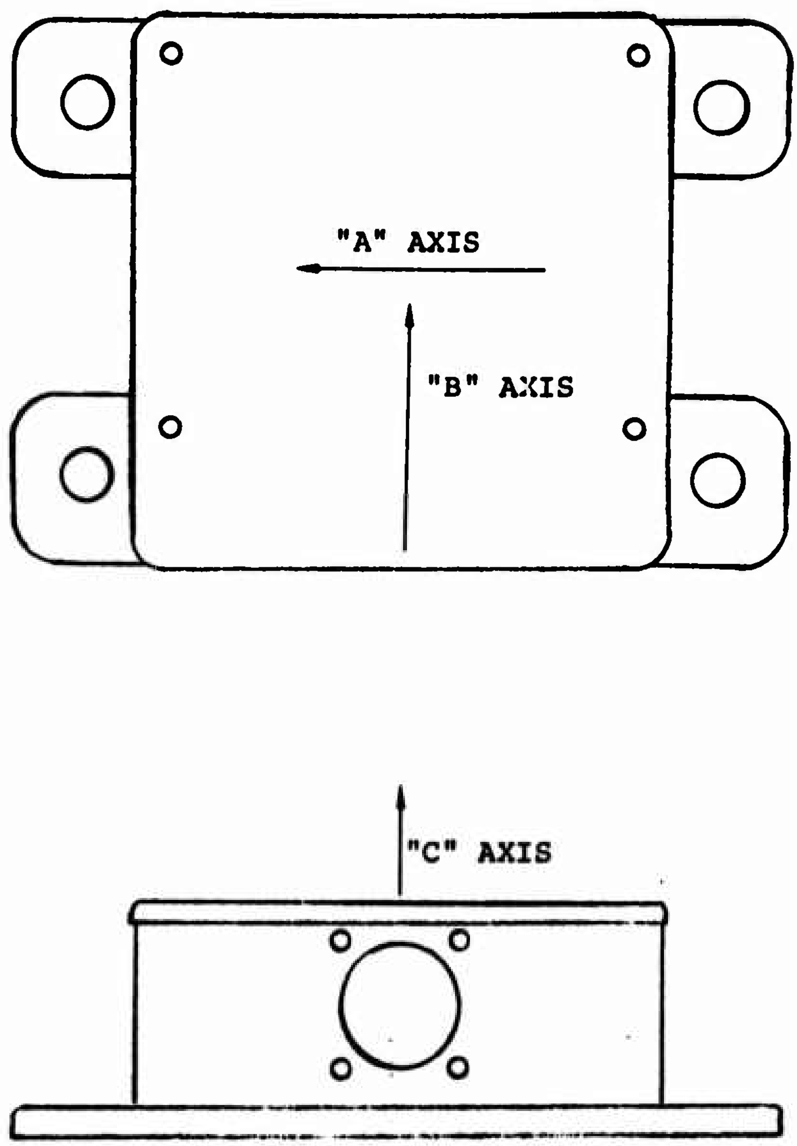
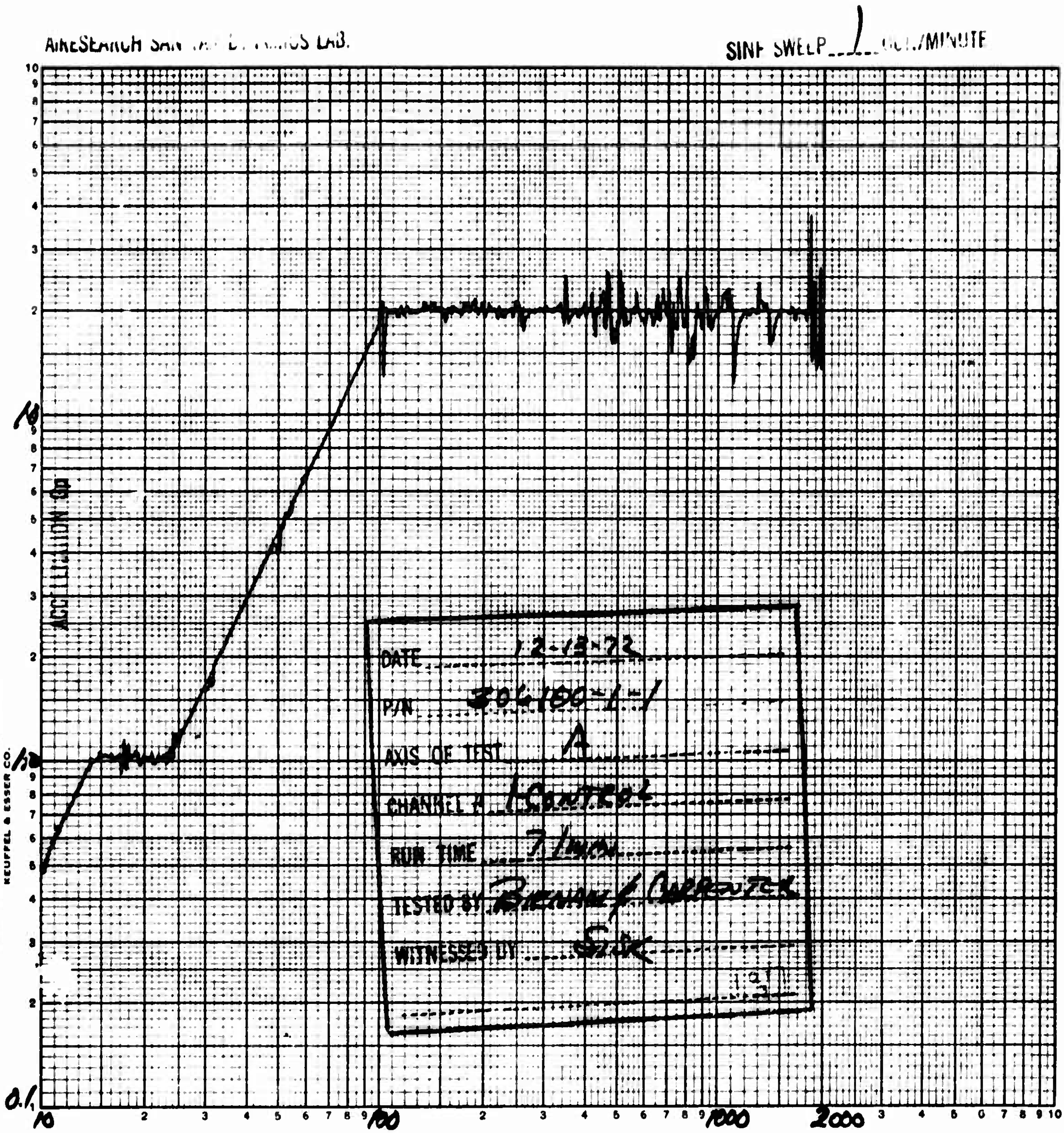


Figure 22. Vibration Axes.



FREQUENCY - CPS

Figure 23. Vibration Test.

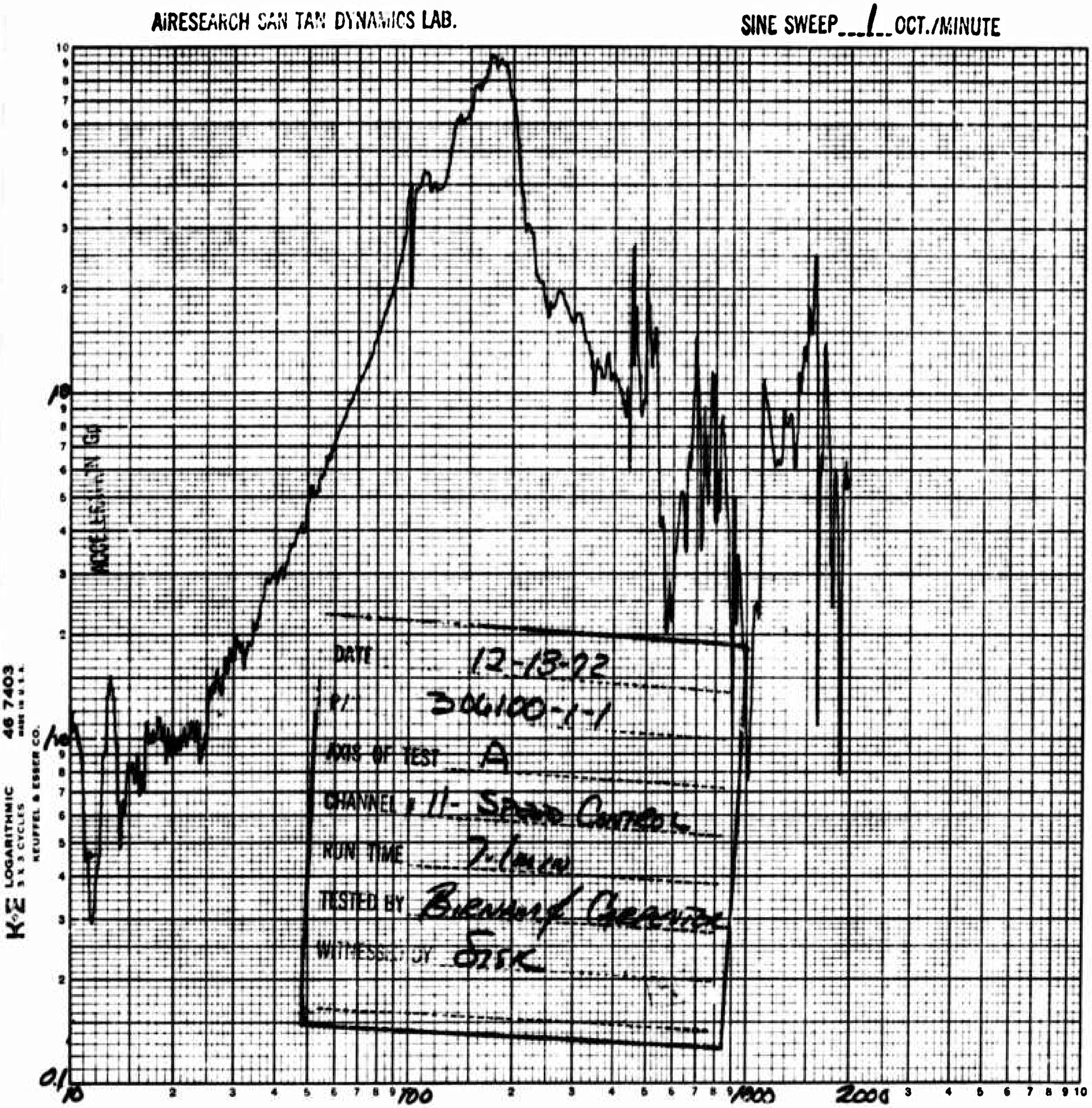
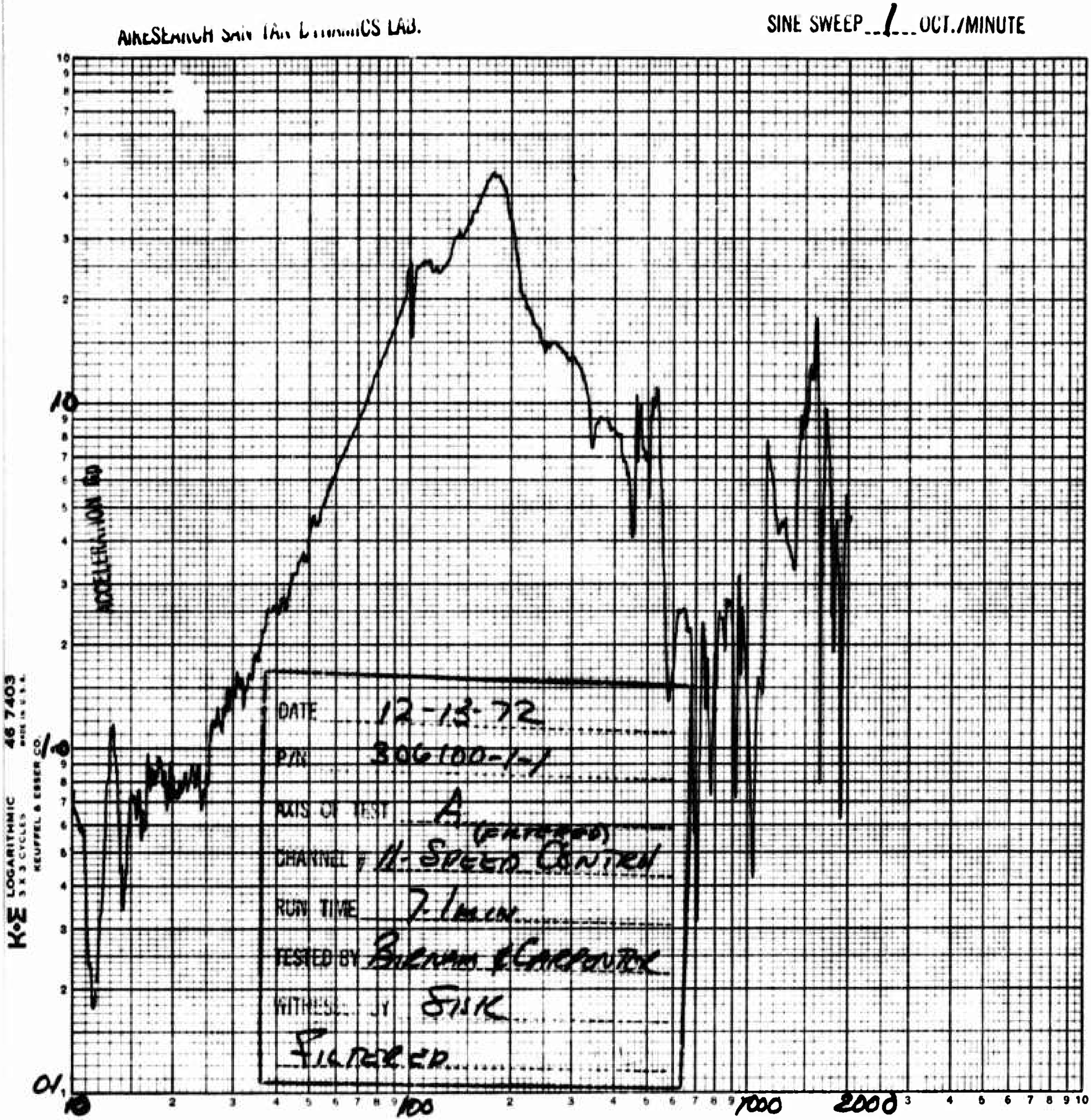
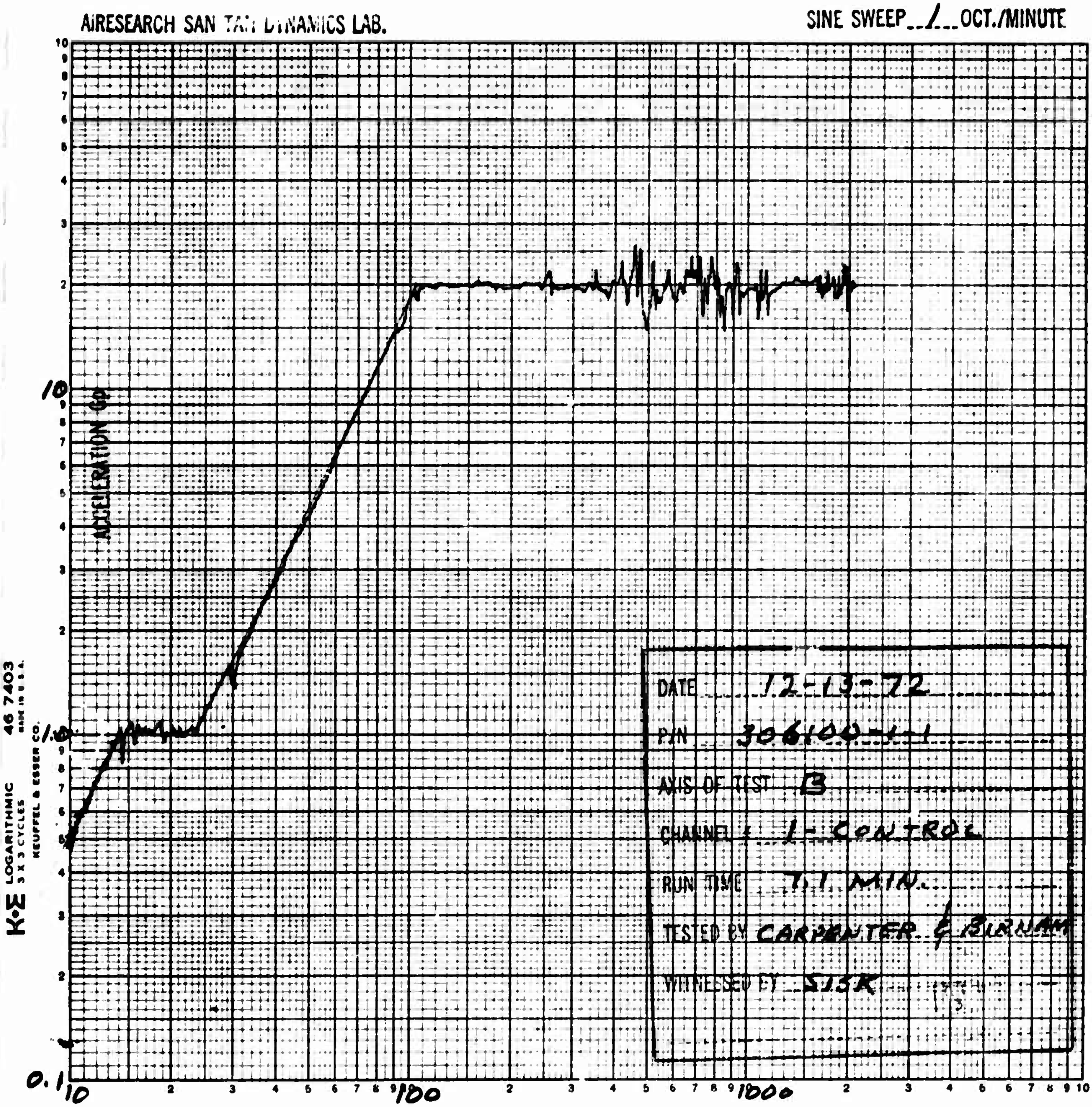


Figure 24. Vibration Test.



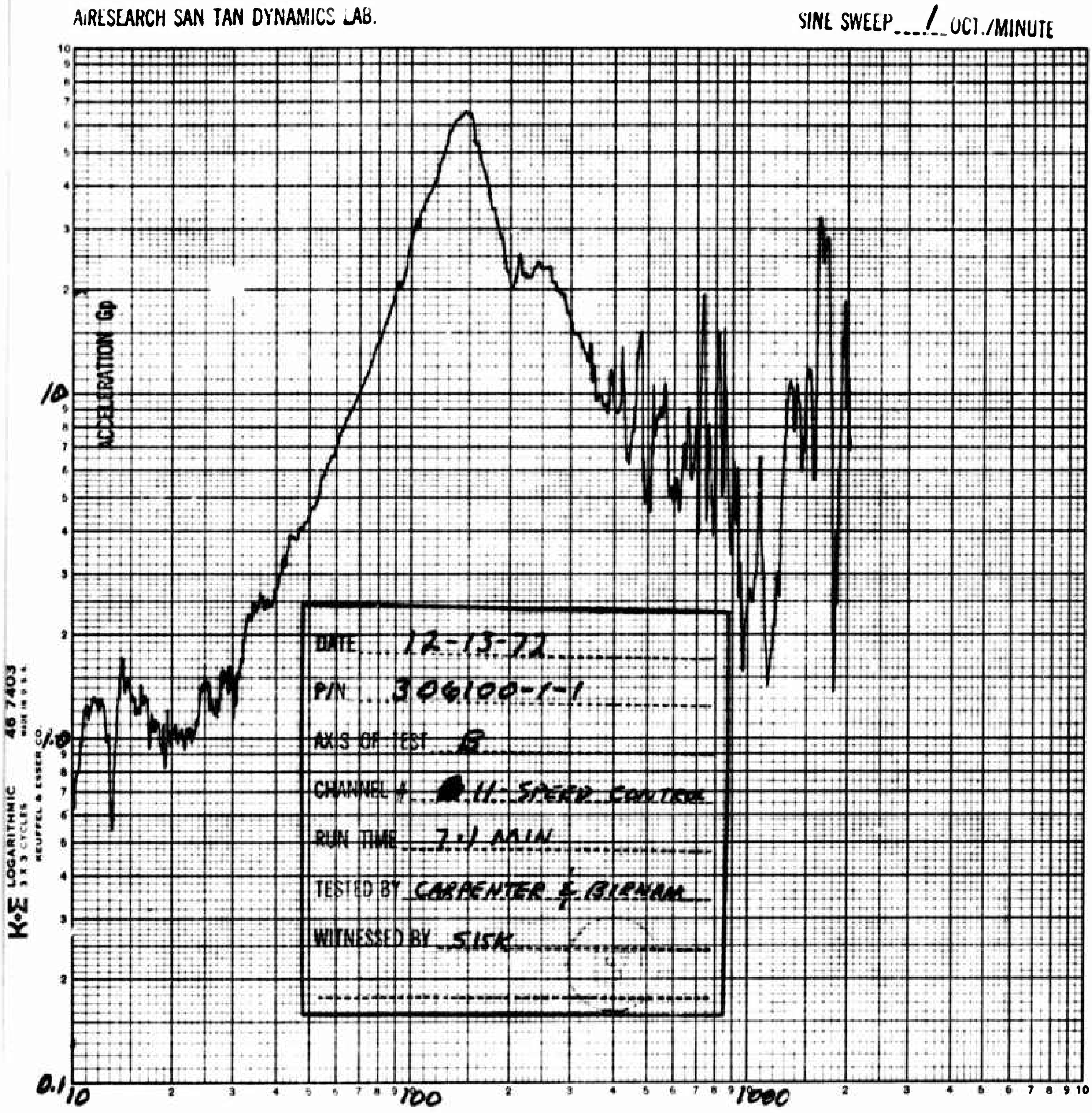
FREQUENCY - CPS

Figure 25. Vibration Test.



FREQUENCY - CPS

Figure 26. Vibration Test.



FREQUENCY - CPS

Figure 27. Vibration Test.

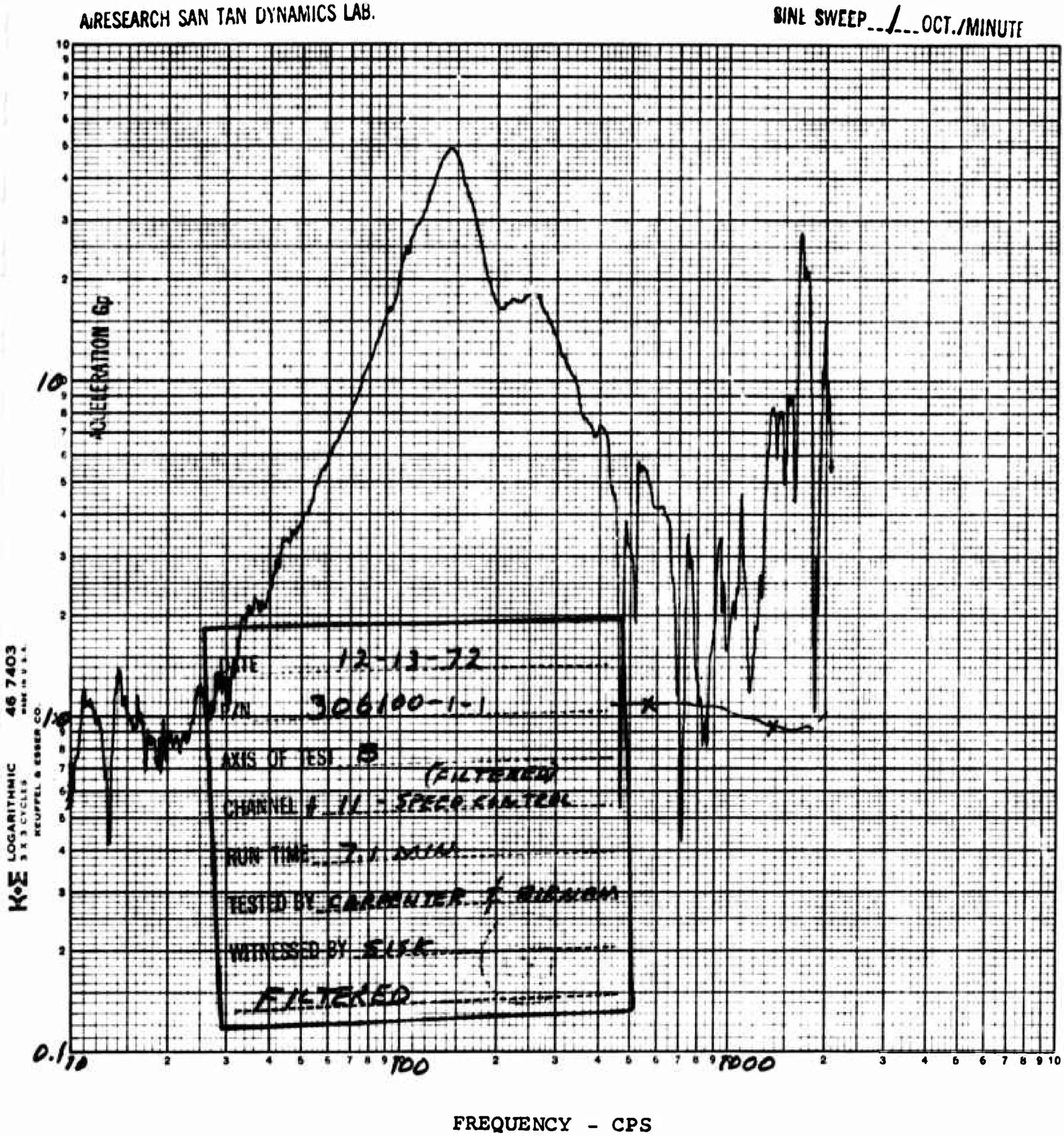
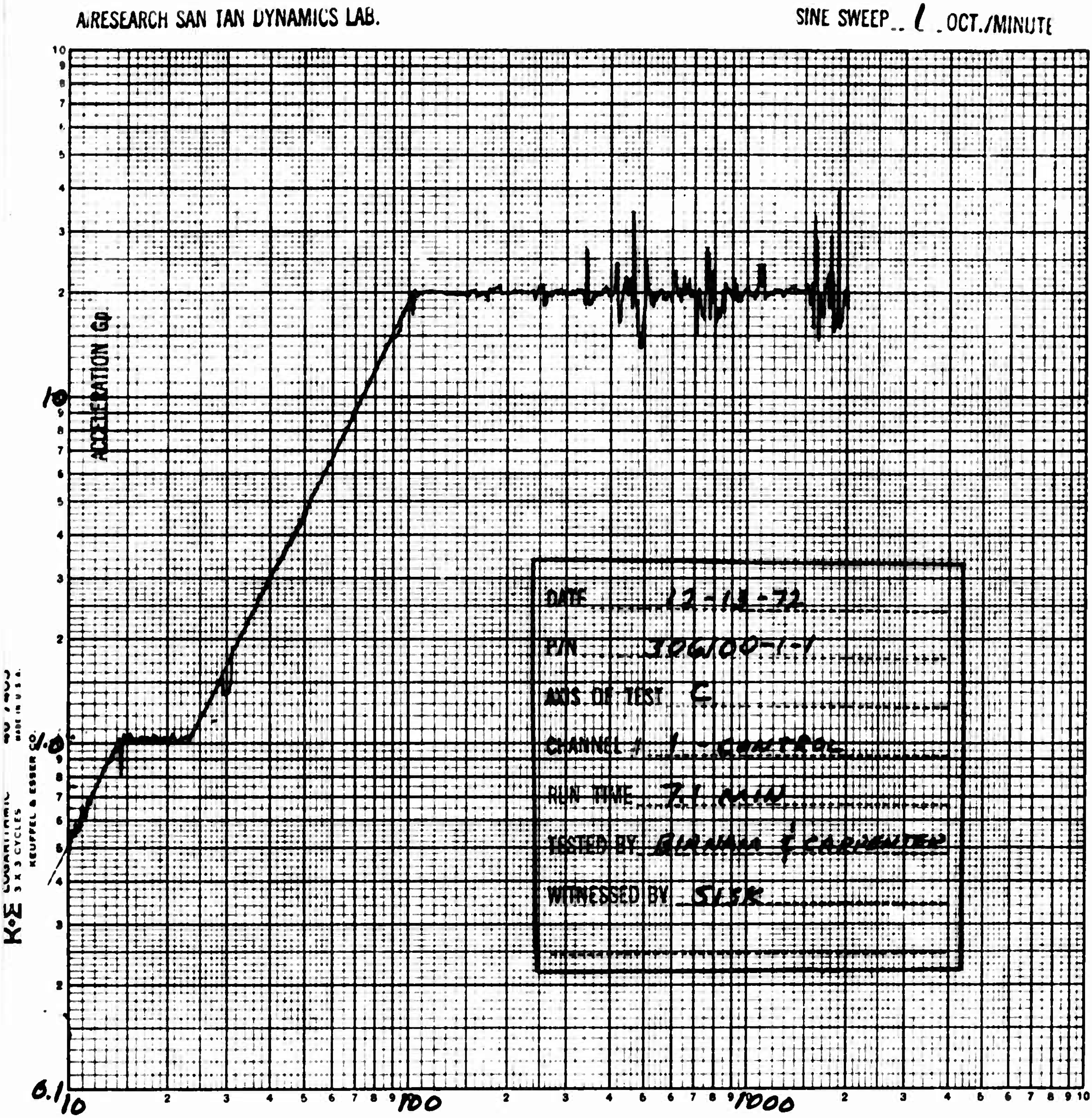
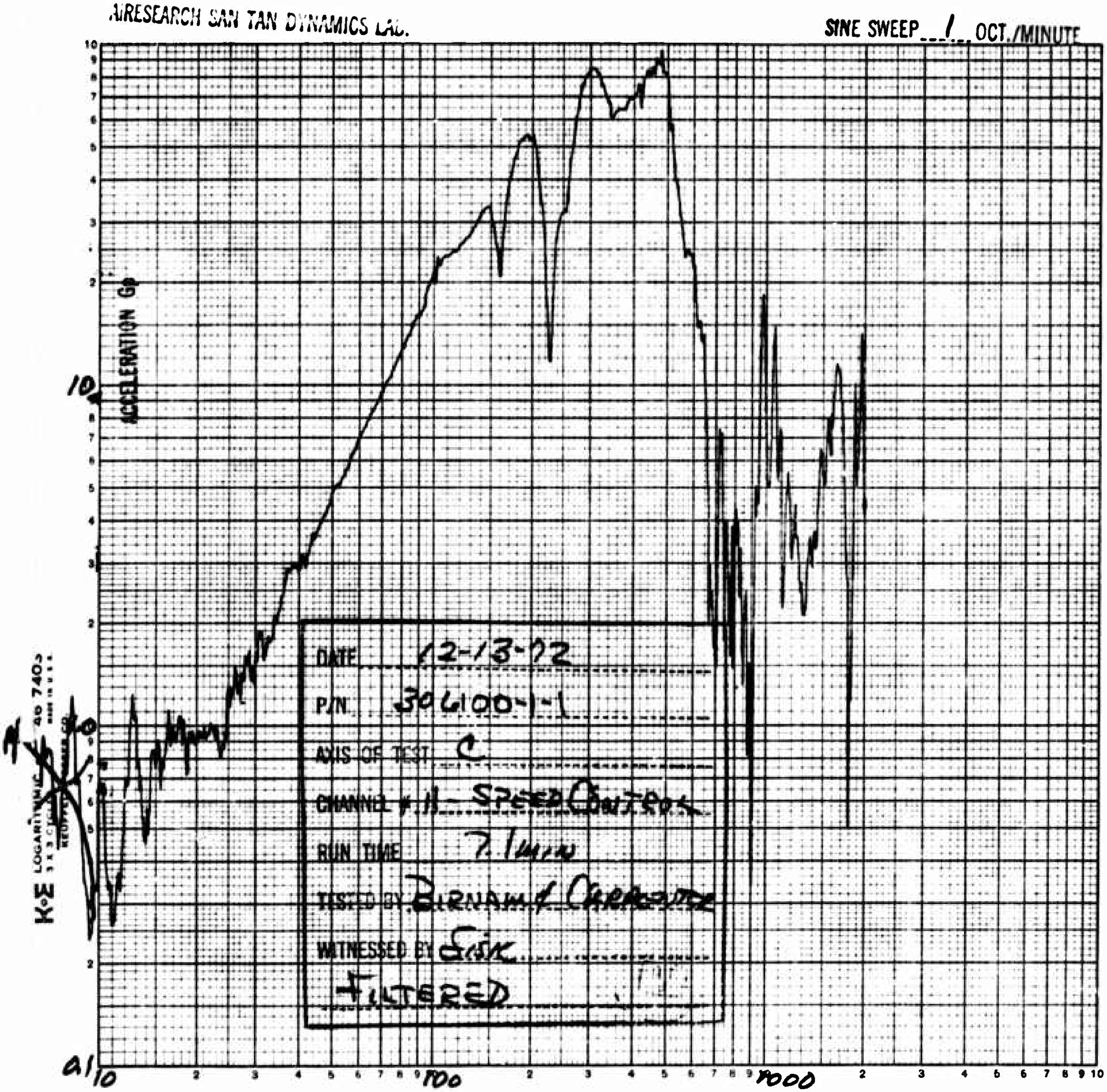


Figure 28. Vibration Test.



FREQUENCY - CPS

Figure 29. Vibration Test.



FREQUENCY - CPS

Figure 30. Vibration Test.

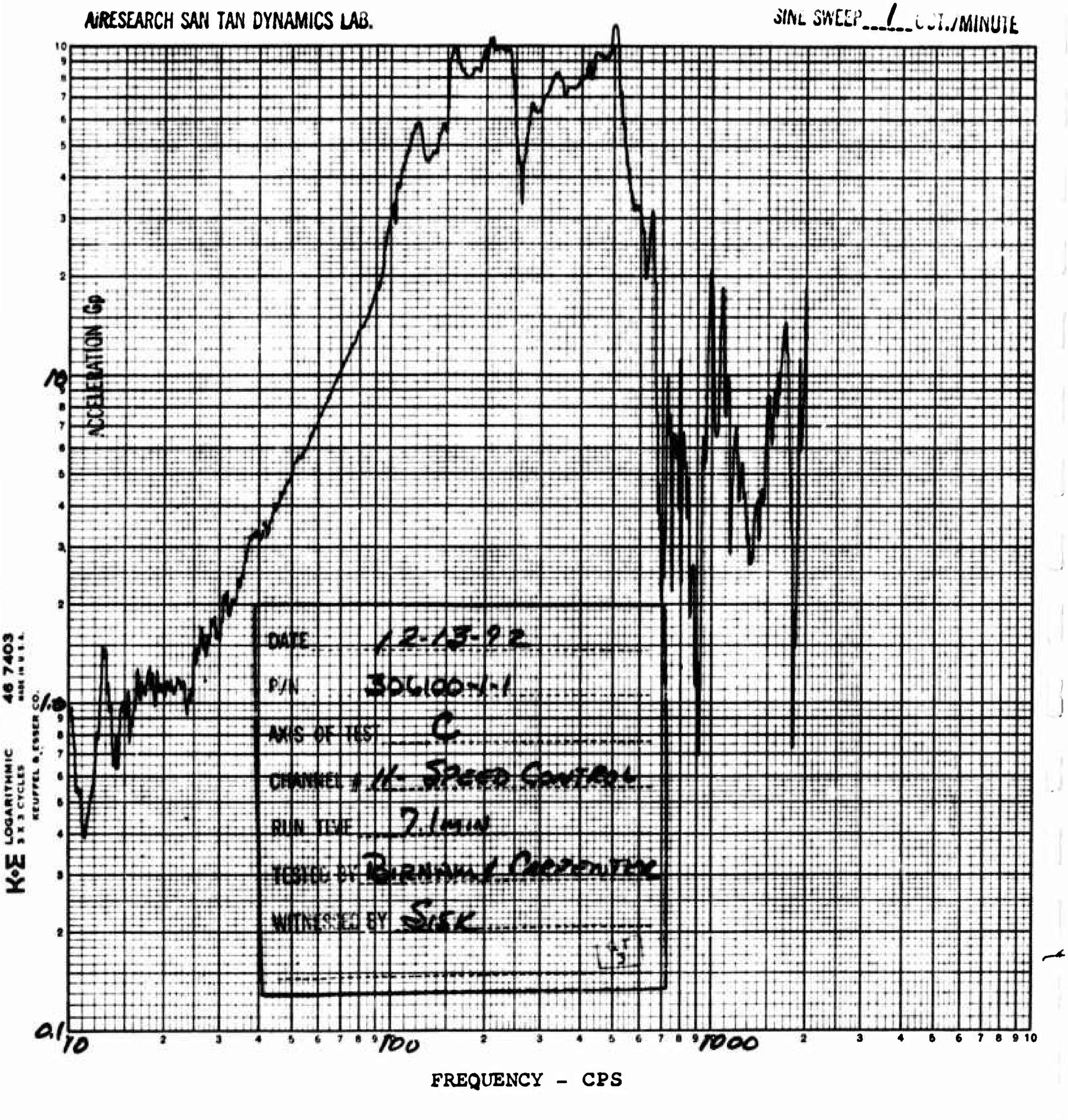


Figure 31. Vibration Test.

4.5.2 Electromagnetic Interference (EMI)

4.5.2.1 Test Summary

Speed Control Part 306100-1-1 Serial No. P-3 was subjected to electromagnetic interference (EMI) testing on December 18 and 19, 1972. The test was conducted at Motorola's EMI test facility in Scottsdale, Arizona. A summary of the tests conducted is presented in Table X. Testing was essentially in accordance with MIL-E-5009D. As verified by the test data, the speed control performance throughout the tests was in compliance with the limits of SC-8029-A, the applicable Harpoon engine model specification. Quality Control requirements were maintained as evidenced by "Certification of Conformance" presented at the conclusion of the data pages of this Section.

4.5.2.2 Test Setup

All tests were performed in a double shielded enclosure, 6 meters long by 3.5 meters wide by 2.4 meters high. The ground plane used was a copper-covered table, 3 meters long by 1 meter wide. The ambient level was at least 6 db below the specification limits. All loads were supplied by the Torque Motor Assembly Part 3740427-1 and the Temperature Sensor Part 377012-1E. The load to the temperature sensor was at room ambient. All connections were made through the Cable Harness Part 3740458. The input was supplied by a Wavetek Model 135 sweep generator at 1131 H_Z to simulate the turbine speed. Refer to Table X for the figure number of the test setup photographs contained herein, that are associated with each test.

4.5.2.3 Test Results

The test specimen was operated with an input voltage of 28.0 vdc and all testing was conducted at laboratory ambient conditions. All

TABLE X. EMI TEST SUMMARY.

	Figures	
	Test Setup	Data
Power line conducted emissions	32	33, 34, 35, and 36
Radiated emission 150 KH_Z - $1GH_Z$	37	38
Radio-frequency conducted susceptbility 50 H_Z - $15KH_Z$	39	40 and 41
Audio-frequency conducted susceptibility $150KH_Z$ - $1GH_Z$	42	43 and 44
Radio-frequency radiated susceptibility $100KH_Z$ - $1GH_Z$	45	46

measured signals, susceptibility responses, and the level of these responses are recorded on the EMI data sheets contained herein. Refer to Table X for the figure numbers of the data sheets associated with each test.

For susceptibility testing, a current meter was monitored for any increase or decrease in current of the input power, which could indicate an error in turbine speed. AiResearch established that if a change in current of ±5 ma occurred, the test specimen was susceptible. The resulting test data showed the current change to be well below this value. For all tests the Speed Control was within the limits specified in MIL-E-5007C and SC-8029-A.

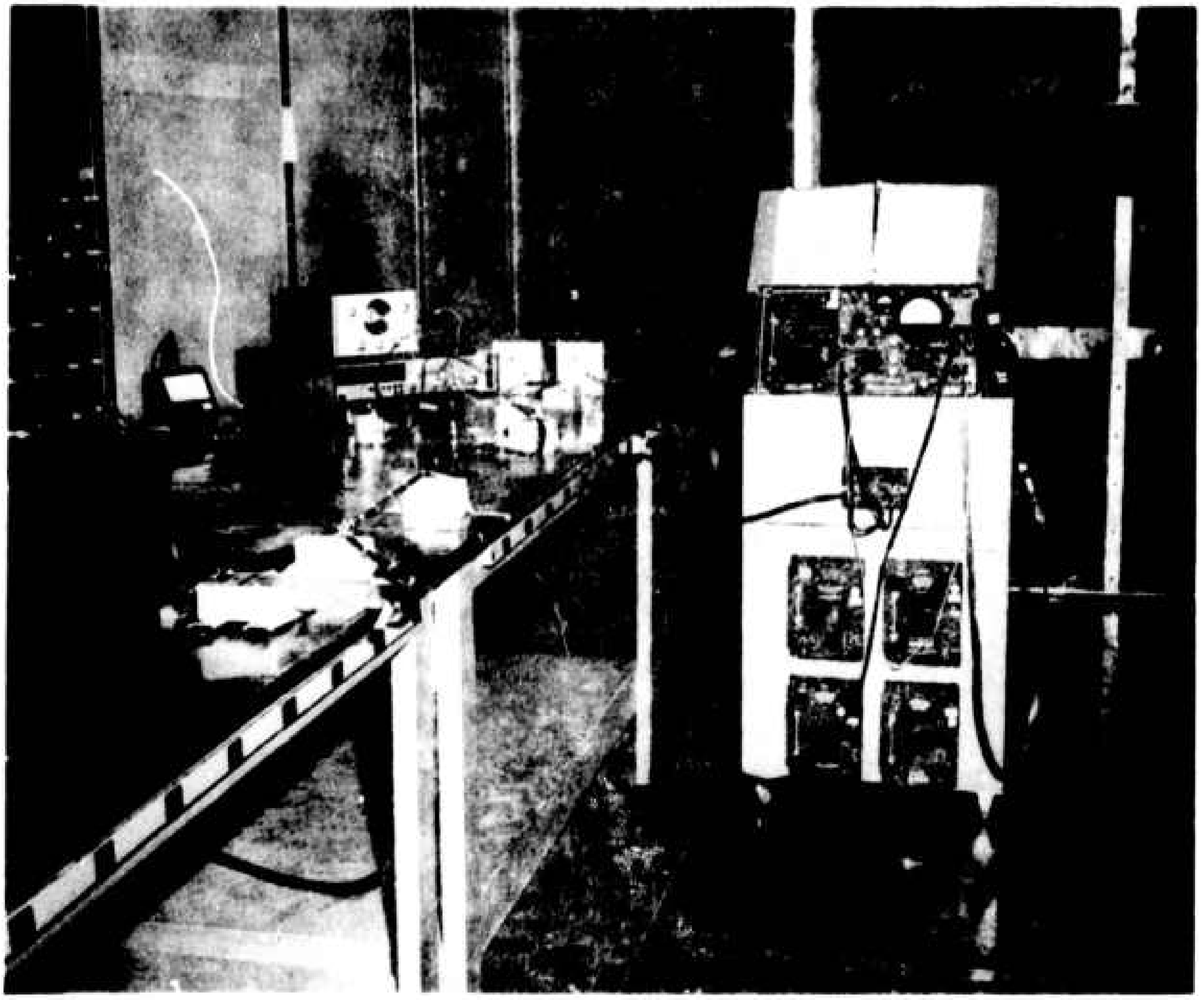


Figure 32. Test Setup Power Line Conducted Emission.

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (A)

DEPARTMENT 4342-008

EQUIPMENT MEASURED SPEED CONTROL

SERIAL NO. P-3

MODE OF OPERATION ON GOVERNOR

DATE OF MEASUREMENT 12-18-72

LINE OR CONDITION +28VDC

SPEC NO. MIL-E 5007

PERFORMED BY R. STONER

TEST PLAN NO.

TYPE OF MEASUREMENT Power Line Conducted Emissions, LSN, 150kHz - 25MHz

FREQ MHz	METER READING dbμv/MHz	CORRECTION FACTORS		CORRECTED READING dbμv/MHz	SPEC LIMIT dbμv/MHz	AMBIENT dbμv/MHz	REMARKS
.150	No measura	ble	Broad	band	Signals		No measurable CW Signals
.500	40			40	119	40	
.600	40			40	116	40	
.800	43			43	113	43	
1.00	47			47	110	47	
1.50	68			68	105	68	
2.00	70			70	101	70	
3.00	64			64		64	
4.00	58			58		58	
5.00	56			56		56	
6.00	50			50		50	
8.00	57			57		57	
10.0	60			60		60	
15.0	48			48		48	
20.0	52			52		52	
25.0	45			45		45	

E3052 12/70

Figure 33.

MOTOROLA INC.
Government Electronics Division
8201 EAST McDOWELL ROAD SCOTTSDALE ARIZONA

ELECTROMAGNETIC INTERFERENCE

UNIT UNDER TEST: SPEED CONTROL

TYPE OF MEASUREMENT: CONDUCTED EMISSION LSN

TEST BY: R. STONER DATE: 12-18-72

APPLICABLE SPECIFICATION: MIL-E-5007C (20dB Relaxed)

LINE OR CONDITION: +28VDC

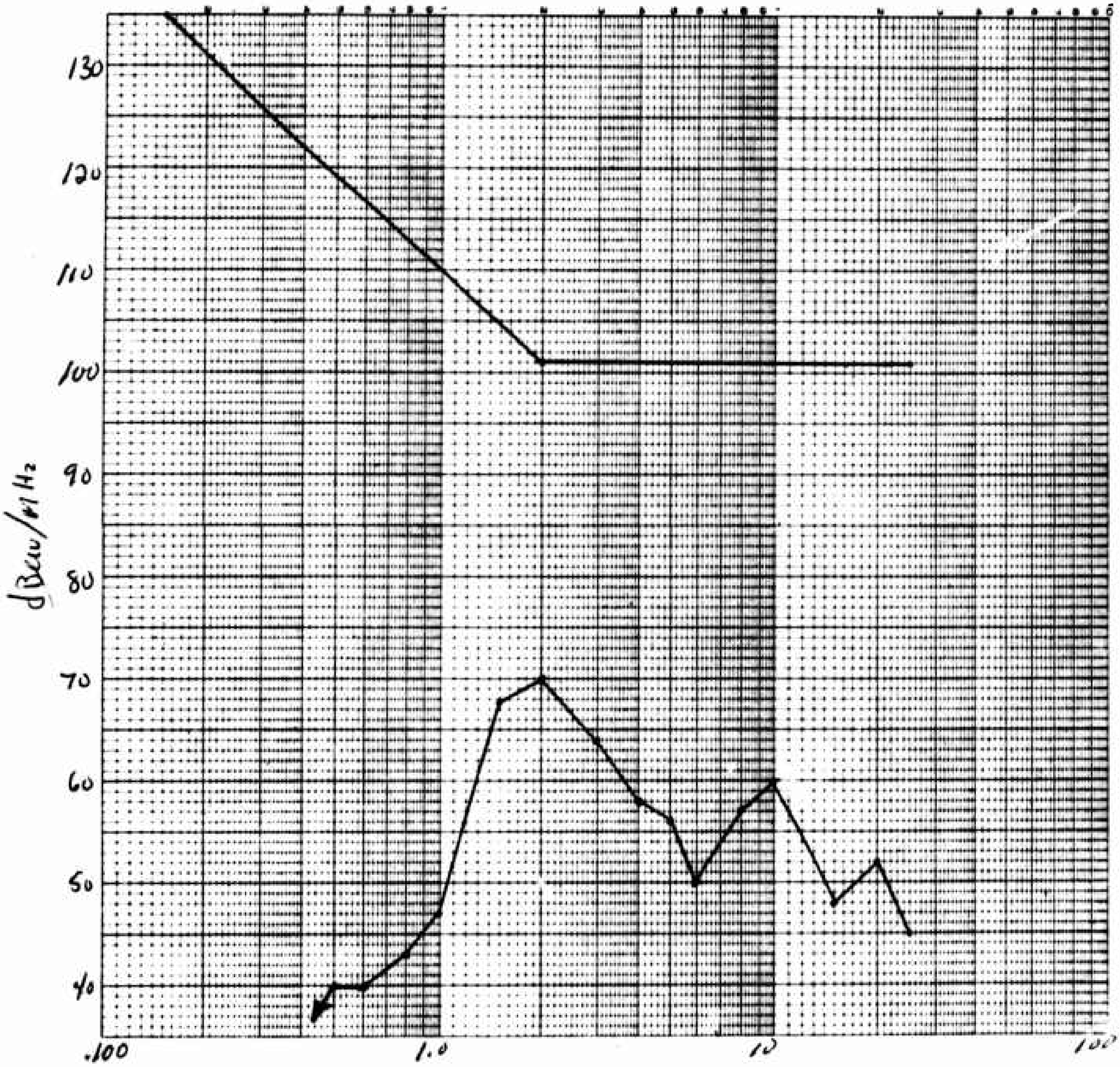


Figure 34

K0131 03 1/69

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (A)

DEPARTMENT 434A-008

EQUIPMENT MEASURED SPEED CONTROL

SERIAL NO. P.3

MODE OF OPERATION: ON GOVERNOR

DATE OF MEASUREMENT 12-18-72

LINE OR CONDITION: 28VDC RETURN

SPEC NO. MIL-E-5007

PERFORMED BY R STONER

TEST PLAN NO.

TYPE OF MEASUREMENT: POWER LINE CONDUCTED EMISSION, LSN, 150KHz - 25MHz

FREQ MHz	METER READING dBµV/MHz	CORRECTION FACTORS		CORRECTED READING dBµV/MHz	SPEC LIMIT dBµV/MHz	AMBIENT dBµV/MHz	REMARKS
.150	No measurable Broadband Signals						No MEASURABLE
↓	↓						CW Signal
.500	40			40	119	40	
.600	44			44	116	44	
.800	47			47	113	47	
1.00	54			54	110	54	
1.50	76			76	105	76	
2.00	76			76	101	76	
3.00	66			66	↓	66	
4.00	60			60		60	
5.00	57			57		57	
6.00	49			49		49	
8.00	57			57		57	
10.0	60			60		60	
15.0	49			49		49	
20.0	52			52		52	
25.0	46			46		46	

E3052 12/70

Figure 35

MOTOROLA INC.
Government Electronics Division
8201 EAST McDOWELL ROAD SCOTTSDALE ARIZONA

ELECTROMAGNETIC INTERFERENCE

UNIT UNDER TEST: Speed Control

TYPE OF MEASUREMENT: Conducted Emission LSN

TEST BY: R. Stoner   DATE: 12-18-72

APPLICABLE SPECIFICATION: MIL-E-5007C (20dB Relaxed)

LINE OR CONDITION: 28VDC Return

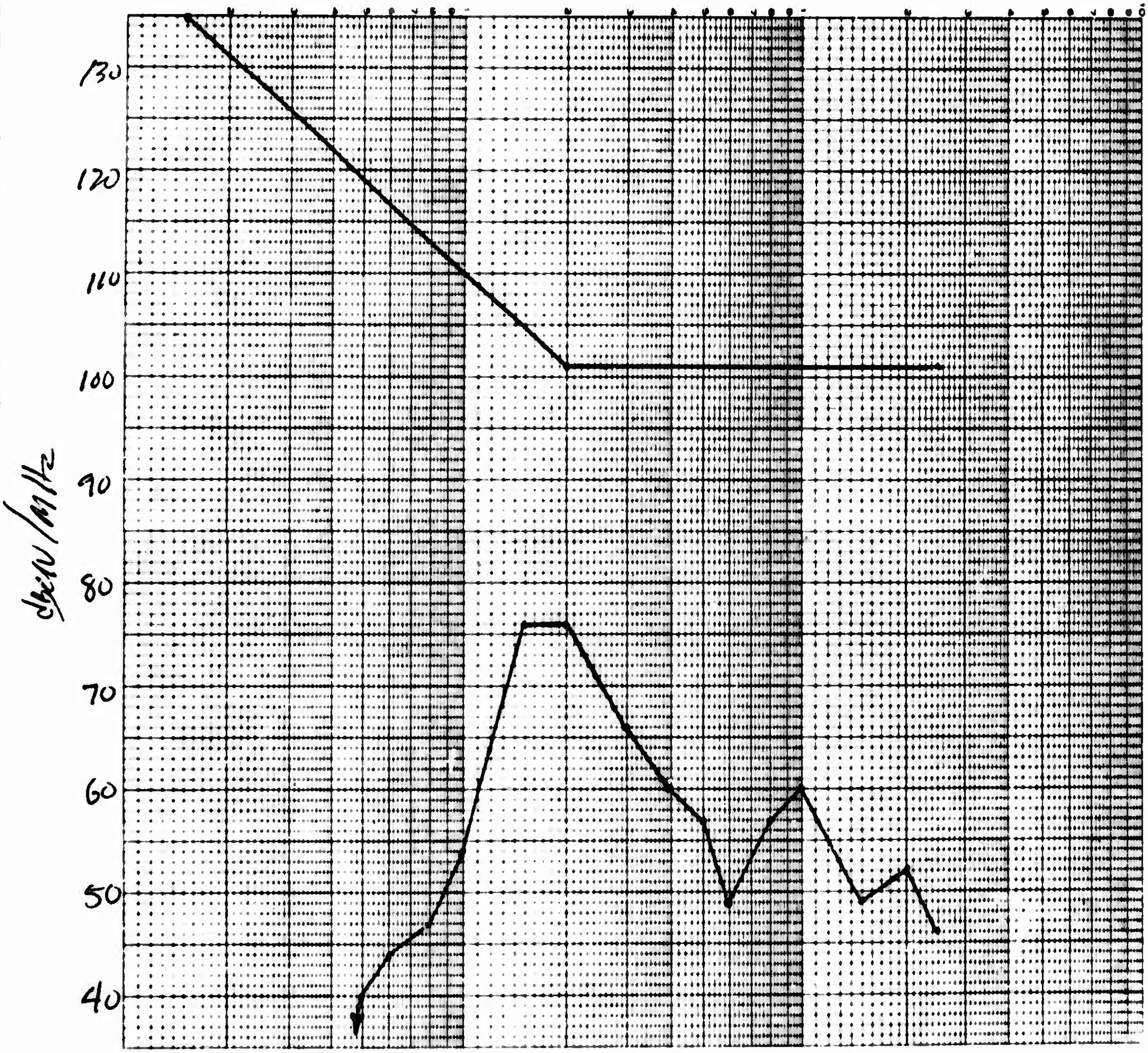


Figure 36

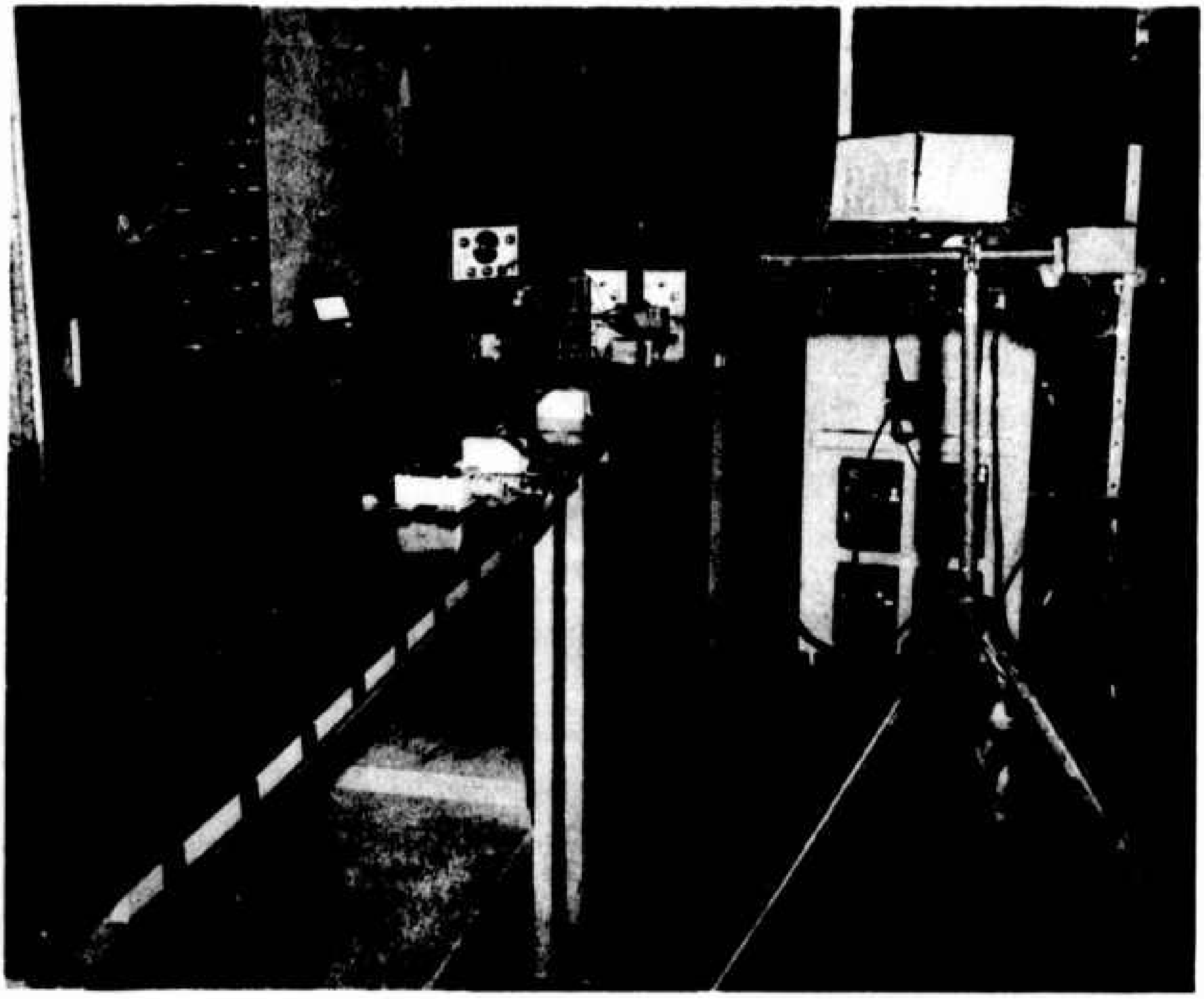


Figure 37. Test Setup Radiated Emissions.

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (A)

DEPARTMENT ____

EQUIPMENT MEASURED SPEED CONTROL

SERIAL NO. P-3

MODE OF OPERATION ON GOVERNOR

DATE OF MEASUREMENT 12-18-72

LINE OR CONDITION ____

SPEC NO MIL-E-5007

PERFORMED BY R. STONER

TEST PLAN NO. ____

TYPE OF MEASUREMENT RADIATED EMISSION 150kHz - 1GHz

FREQ MHz	METER READING dBuv/MHz	CORRECTION FACTORS ANT	CABLE	CORRECTED READING dBuv/MHz	SPEC LIMIT dBuv/MHz	AMBIENT dBuv/MHz	REMARKS
.150	NO MEASURABLE SIGNALS, BROADBAND OR CW						
1000							

E3052 12/70

Figure 38

Figure 39. Test Setup Radio-Frequency Conducted Susceptibility.

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (B)

DEPARTMENT: 4342-008

EQUIPMENT MEASURED: SPEED CONTROL

SERIAL NO.: P 3

MODE OF OPERATION: ON GOVERNOR

DATE OF MEASUREMENT: 12-19-72

LINE OR CONDITION: +28VDC

SPEC NO: MIL-E-5007

PERFORMED BY: V. SCHIFANO

TEST PLAN NO:

TYPE OF MEASUREMENT: RF CONDUCTED SUSCEPTIBILITY 150kHz - 1000MHz

FREQ MHz	Scan Level Vrms	THRESHOLD Vrms	Spec Limit Vrms			REMARKS
.150	0.2	No Response	0.1			
1000.0						

E3053 12/70 CTL 723

Figure 40

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (B)

DEPARTMENT 4342-008

EQUIPMENT MEASURED SPEED CONTROL

SERIAL NO. P. 3

MODE OF OPERATION ON GOVERNOR

DATE OF MEASUREMENT 12-19-72

LINE OR CONDITION 28VDC Return

SPEC NO MIL-E-5007

PERFORMED BY V. SCHIFANO

TEST PLAN NO

TYPE OF MEASUREMENT RF CONDUCTED SUSCEPTIBILITY 150kHz-1000MHz

FREQ MHz	SCAN LEVEL Vrms	THRESHOLD Vrms	SPEC LIMIT Vrms			REMARKS
.150	0.2	No Response	0.1			
1000.0						

E3053 12/70 CTL 723

Figure 41

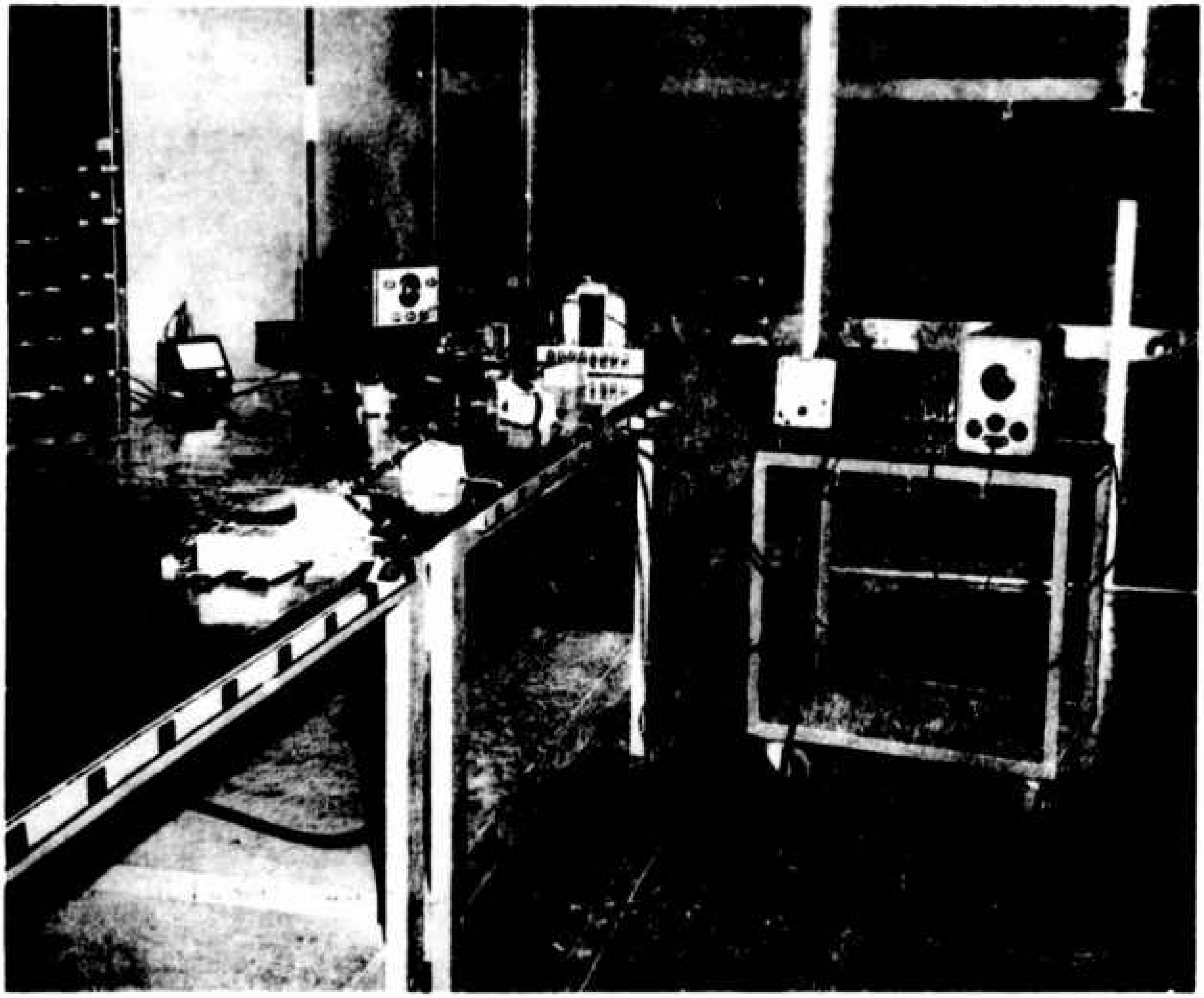


Figure 42. Test Setup Audio-Frequency Conducted Susceptibility.

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (B)

DEPARTMENT 4342-008
EQUIPMENT MEASURED SPEED CONTROL
SERIAL NO. P-3
MODE OF OPERATION ON GOVERNOR
DATE OF MEASUREMENT 12-19-72
LINE OR CONDITION +28 VDC
SPEC NO. MIL E-5007
PERFORMED BY V. SCHIFANO
TEST PLAN NO
TYPE OF MEASUREMENT AF CONDUCTED SUSCEPTIBILITY 50Hz - 15kHz

FREQ Hz	SCAN LEVEL Vrms	THRESHOLD Vrms	SPEC LIMIT Vrms			REMARKS
50	3.0	No Response	3.0			
↓	↓	↓	↓			
15,000						

E3053 12 70 CTL 723

Figure 43

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (B)

DEPARTMENT 6342-008
EQUIPMENT MEASURED SPEED CONTROL
SERIAL NO. P 3
MODE OF OPERATION: ON GOVERNOR
DATE OF MEASUREMENT 12-19-72
LINE OR CONDITION: 28VDC Return
SPEC NO MIL-E-5007
PERFORMED BY U. SCHIFANO
TEST PLAN NO
TYPE OF MEASUREMENT AF CONDUCTED SUSCEPTIBILITY 50Hz - 15KHz

FREQ Hz	SCAN LEVEL Vrms	THRESHOLD Vrms	SPEC LIMIT Vrms			REMARKS
50	3.0	No Response	3.0			
15,000						

E3053 12 70 CTL 723

Figure 44

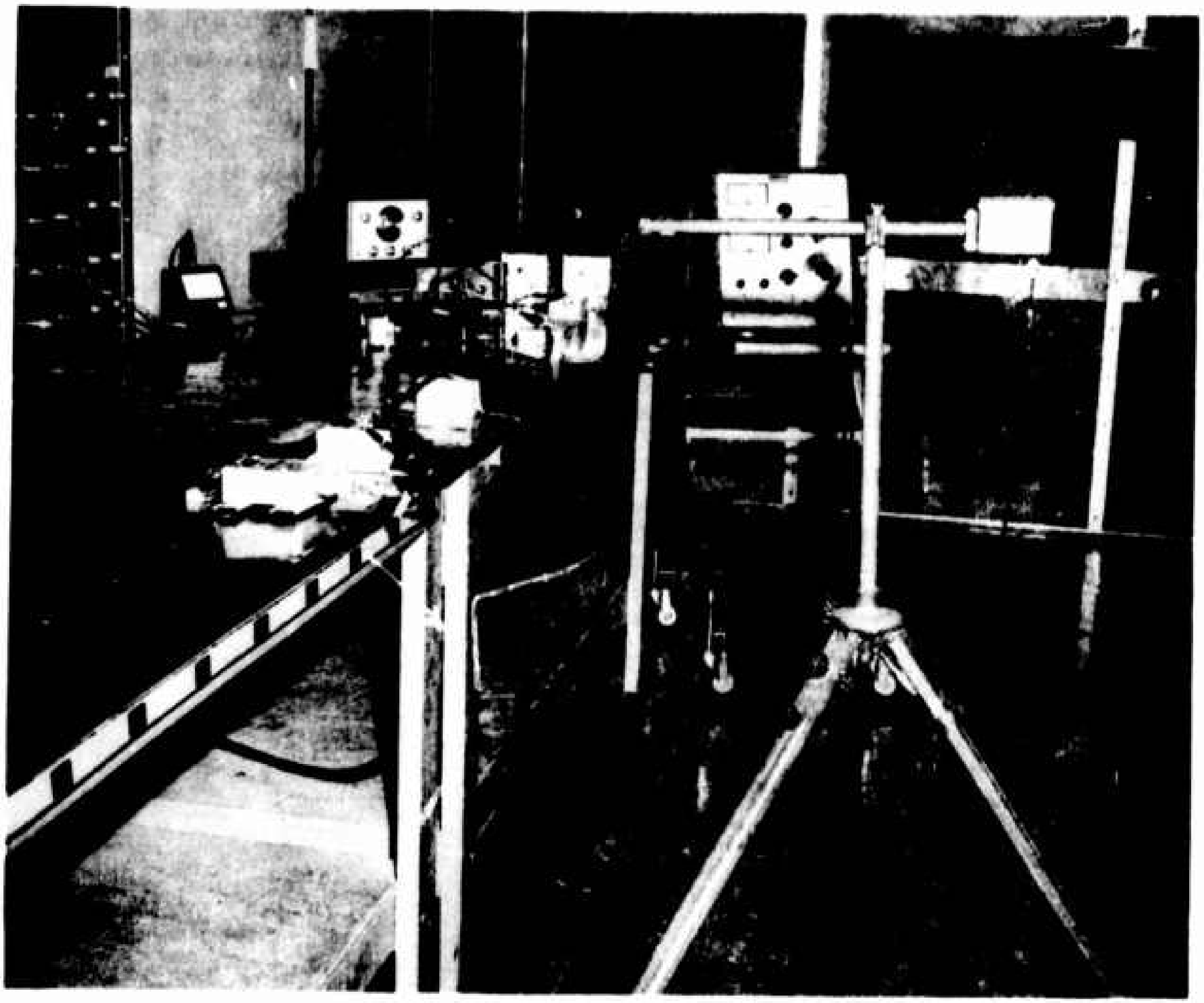


Figure 45. Test Setup Radiated Susceptibility.

MOTOROLA INC.
Government Electronics Division

ELECTROMAGNETIC INTERFERENCE TEST DATA SHEET (B)

DEPARTMENT 4342-008

EQUIPMENT MEASURED Speed Control

SERIAL NO. P-3

MODE OF OPERATION ON Governer

DATE OF MEASUREMENT 12-19-72

LINE OR CONDITION

SPEC NO. MIL-E-5007

PERFORMED BY V. Schifano

TEST PLAN NO

TYPE OF MEASUREMENT Radiated Susceptibility

FREQ MHz	SCAN LEVEL Vrms	THRESHOLD Vrms	SPEC LIMIT Vrms			REMARKS
.100	0.2	No Response	0.1			
↓	↓	↓	↓			
1000.0						

E3053 12/70 CTL 723

Figure 46

MOTOROLA INC. Government Electronics Division

February 2, 1973

CERTIFICATION OF CONFORMANCE

I hereby certify that a Speed Control Unit was tested by Motorola for Airesearch Co., P.O. 509382, and that such assemblies were processed by Motorola in accordance with all quality requirements of the purchase order. Objective evidence of test and inspection of this material is on file and may be reviewed at Motorola upon request.

Bob Whitlatch
QA. Project Manager

8201 E. McDOWELL ROAD SCOTTSDALE, ARIZONA 85257 (602) 949-3033

4.6 Investigation of Facility Inlet Temperature Stratification

Difficulties experienced in setting the electromechanical fuel control governor in the test facility initiated an investigation of the facility ram air supply. With use of high response thermocouples in the inlet duct forward of the bellmouth as shown in Figure 47, it was ascertained that 20 to 30°F temperature variations existed in the ram air supply. However, further tests revealed the existence of a temperature stratified airstream.

Temperature variations with ram air supplied, as shown in Figure Figure 47, are listed in Table XI. As indicated, temperature measurements taken with thermocouples 2 through 5 at the bellmouth, disclosed a temperature differential (ΔT) of 21°F at the test conditions specified. In order to correct this problem, modifications to the air delivery system were incorporated to provide better mixing. As indicated in Figure 48, hot and cold air were introduced from opposite directions rather than as merging flowpaths as shown in Figure 47. Results of tests conducted following the facility modification, showed a ΔT of less than 5°F (see Table XII). In addition, the procedures for supplying the inlet air were revised and test results, as presented in Table XIII, show a total temperature variation of only 1°F. Subsequent engine tests resulted in satisfactory fuel control adjustments.

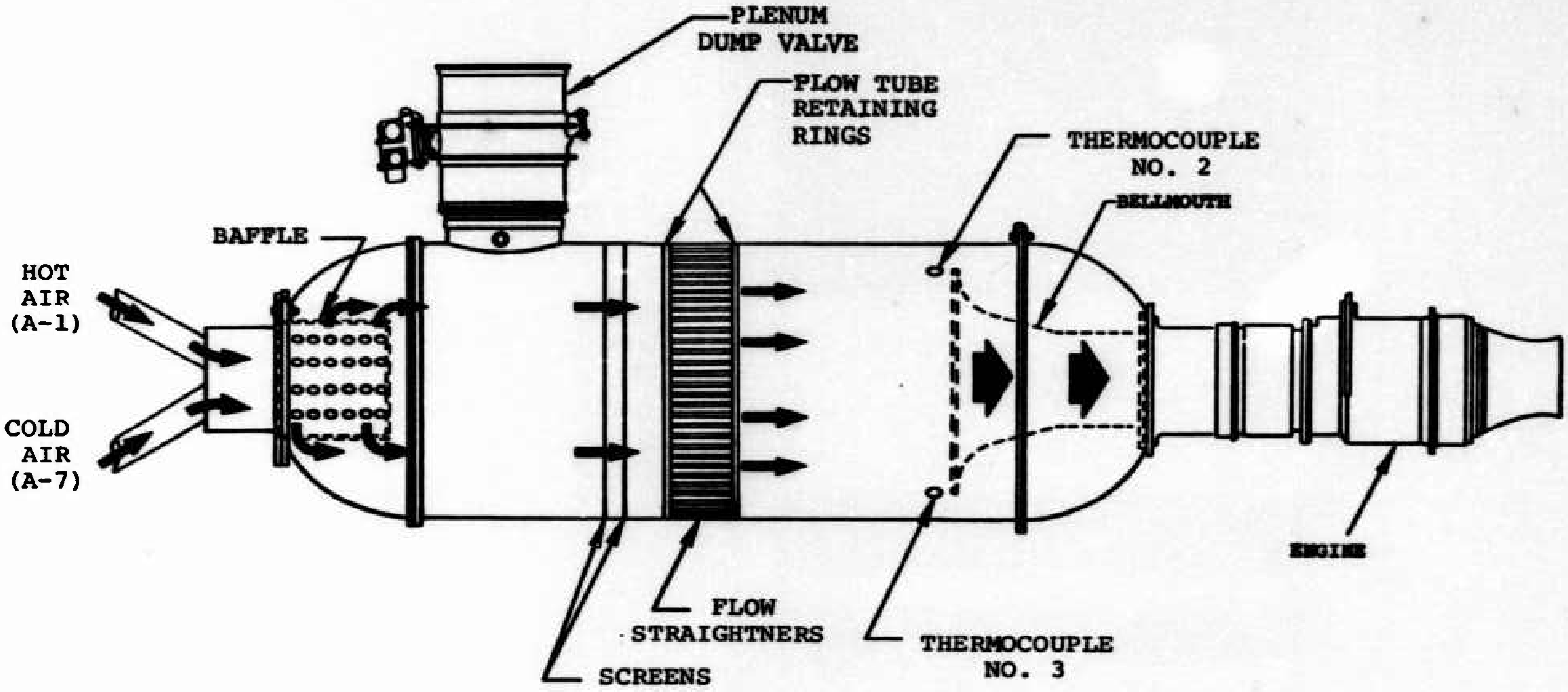


Figure 47. Inlet Plenum Mixing Chamber.

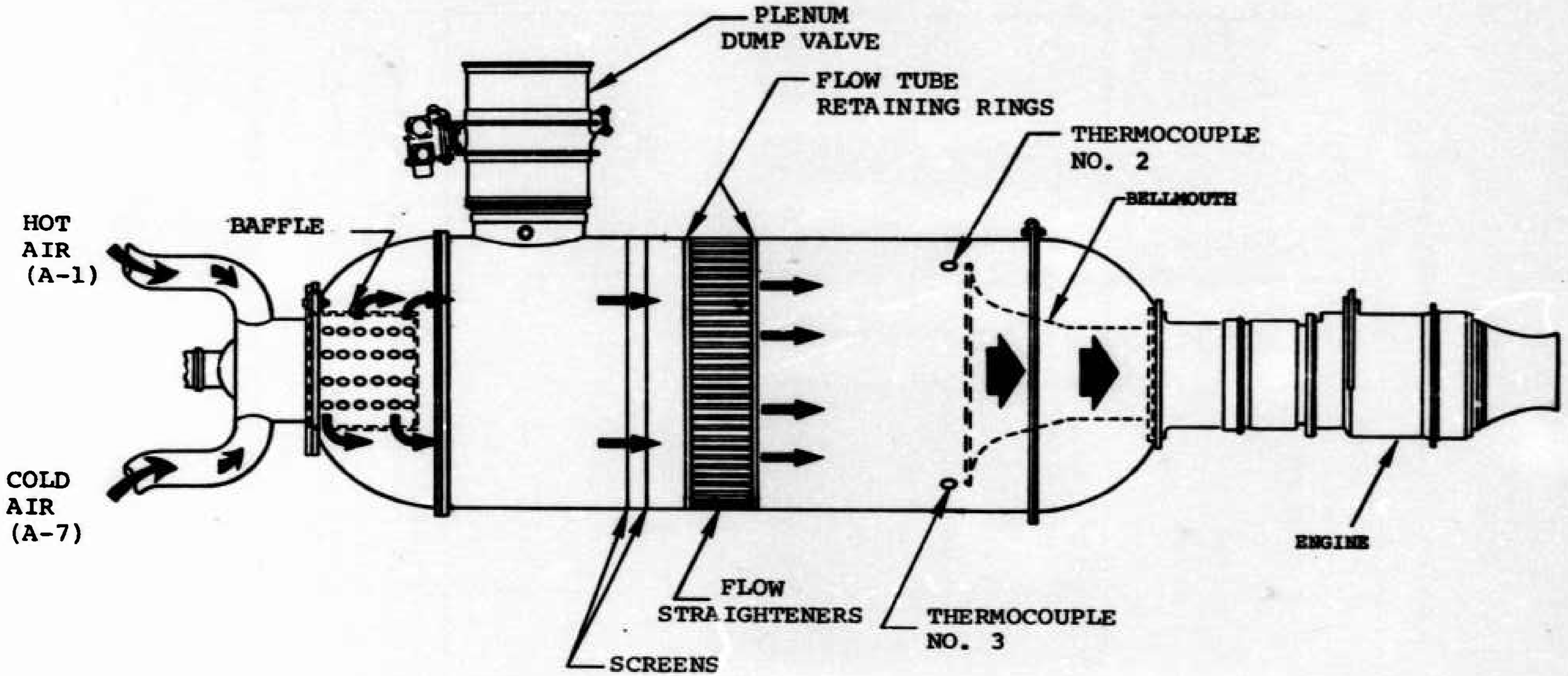


Figure 48. Inlet Plenum Mixing Chamber with Modified Air Supply System.

TABLE XI. COMPRESSOR INLET TEMPERATURE VARIATION.

P_{t2}	Wa	T_{t2}
4.0 inches Hg Ram ΔP	10.0 lbs per sec	(2) = 165°F (3) = 186°F (4) = 175°F (5) = 174°F ΔT = 21°F
A-1 and A-7 temperatures into plenum		
	A-1 (1) = 277°F (2) = 276°F	A-7 (1) = 53°F (2) = 53°F

TABLE XII. COMPRESSOR INLET TEMPERATURE VARIATIONS AFTER FACILITY MODIFICATION.

P_{t2}	Wa	T_{t2}
4.0 inches Hg Ram ΔP	10.0 lbs per sec	(2) = 183°F (3) = 183°F (4) = 182°F (5) = 179°F ΔT = 4°F
A-1 and A-7 temperatures into plenum		
	A-1 (1) = 291°F (2) = 292°F	A-7 (1) = 51°F (2) = 52°F

TABLE XIII. COMPRESSOR INLET TEMPERATURE VARIATIONS FOLLOWING MODIFICATIONS TO PROCEDURE.

P_{t2}	Wa	T_{t2}
6.0 inches Hg Ram ΔP	13.0 lbs per sec	(2) = +170°F (3) = +169°F (4) = +169°F (5) = +169°F ΔT = 1°F
A-1 and A-7 temperatures to plenum		
	A-1 (1) = 188°F (2) = 189°F	A-7 (1) = 143°F (2) = 143°F

4.7 Engine Rear Thrust Bearing Operating Life Extension

A program was initiated to improve the engine rear bearing life after -65°F soaking. The program consisted of selecting a lubricant better suited for low-temperature operation, improving the cooling to the engine rear bearing, and regulating the amount of axial thrust loading on the rear bearing. The improvements resulting from this program and the tests conducted to evaluate them are summarized as follows:

- Mobil Jet II (MIL-L-23699) oil was selected as a replacement for Krytox 143AC. Bearing test rig and engine tests verified that Mobil Jet II was a better lubricant at low-temperature (-65°F) conditions.

- The rear bearing cooling air-flow area was increased 100 percent, by enlarging the cooling air holes in the turbine shaft as shown in Figure 49, and in the slinger as shown in Figure 50. This resulted in a bearing temperature reduction of approximately 150°F during testing.

- A 1/2 inch diameter relief valve to regulate the amount of axial thrust load imposed on the rear bearing (see Figure 51) was used in place of the 4-hole orifice plate. This relief valve method, with a 20 psi differential cracking pressure, regulates the pressure in the thrust-balance cavity and causes a forward thrust loading, whereas the orifice plate has a non-regulated bleed-off of the balance-cavity pressure, permitting the bearing axial loading to be in either direction. Engine tests to evaluate this regulated axial loading were satisfactory.

These changes, as a combination, were effective in increasing the bearing life. The reduced temperature level in the rear bearing

assured that the Mobil Jet II oil maintained the proper lubrication qualities at the high-temperature end, while being better than Krytox at the low-temperature end of the engine operating range. In addition, a constant forward axial loading of the rear bearing as provided by the relief valve, was found to be desirable.

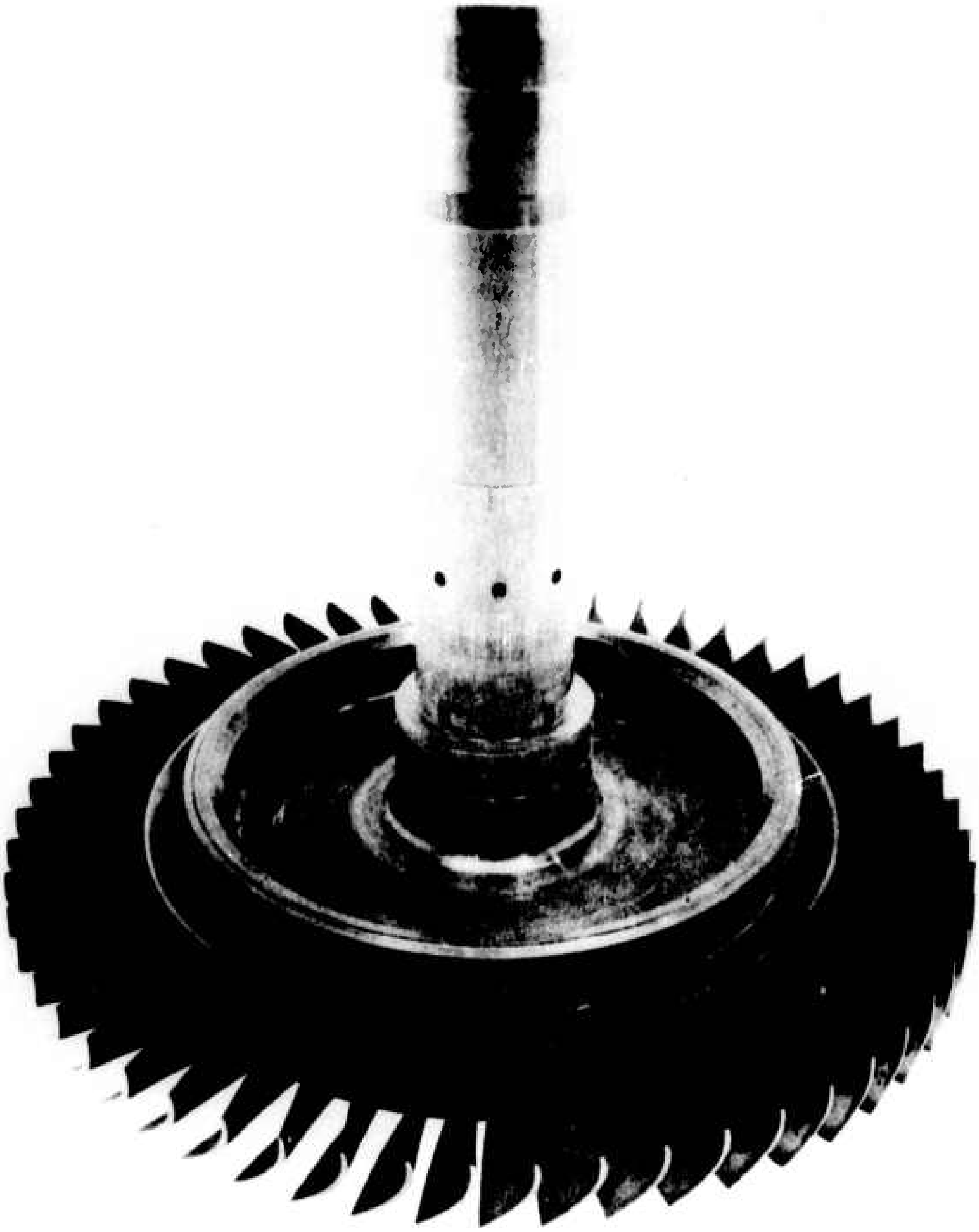


Figure 49. Enlarged Cooling Air Holes in Turbine Shaft.

Figure 50. Slinger with Enlarged Cooling Holes.

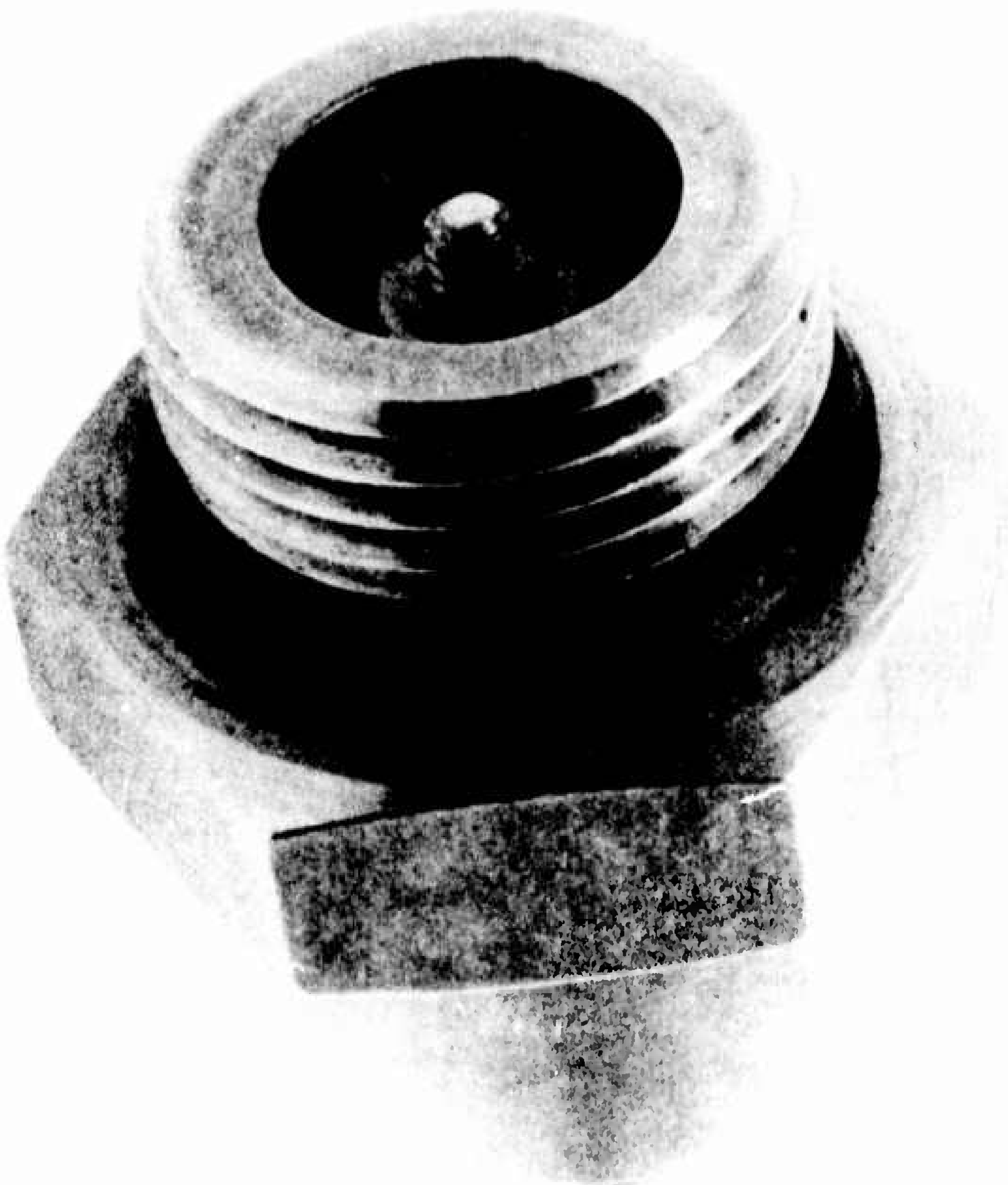


Figure 51. Thrust-Balance Cavity Relief Valve, 1/2 Inch in Diameter

4.7.1 Lubrication Evaluation Tests

A series of bearing rig tests were conducted to evaluate Krytox 143 AC and Mobil Jet II (MIL-L-23699) lubricants. Testing was conducted under low- and high-temperature conditions.

4.7.1.1 Low Temperature

A total of 20 minus 65°F cold-soak tests were conducted, 14 using Krytox and 6 using Mobil Jet II. The soaks were of 3-hour duration except for three that were 10 hours in length. In general, the conclusions reached from these tests were:

(a) All bearings tested with Mobil Jet II oil acquired either no skid damage or tolerable skid damage.

(b) Bearings tested with Krytox 143 AC oil acquired some measure of ball skid damage.

(c) The thrust bearing can operate for 3 minutes with no available oil supply other than the residual oil in the bearing. The oil in this case can be either Mobil Jet II or Krytox 143 AC.

4.7.1.2 High Temperature

High-temperature rig tests essentially imposing conditions simulating engine running, indicated that the oil sump can be filled with sufficient Mobil Jet II to permit 30 minutes of engine running. Two test runs were made to determine the quantity of oil required, up to the bearing failure point. Both runs were well over 1 hour duration with an oil consumption of approximately 100 cc per test. The quantity of oil remaining at the end of the tests was approximately 30 cc. The bearing temperature just prior to failure was 420°F.

4.7.2 Engine Testing

Two engine builds were completed which included the increased cooling to the rear bearing and installation of the 1/2 inch diameter relief valve, with a 20 psi differential cracking pressure, on the thrust-balance cavity.

The first test was conducted with use of Krytox 143 AC lubricant in the rear bearing. The test consisted of a standard acceptance test followed by IFRT No. 1 test, including the 10 hour, -65° soak. Examination of the bearing after the test showed indications of excessive ball skidding on the inner race. The second build and test of the engine was the same as the first build, except for the use of Mobil Jet II (23699) lubricant in the rear bearing. The condition of the bearing following this test was excellent, with no evidence of ball skidding.

An additional engine was built and instrumented to measure axial thrust loads on the rear bearing. With the 4-hole orifice plate,the bearing thrust loads were found to be in either direction, but generally aft. Several runs were conducted with the 1/2 inch relief valve, and the bearing thrust loads were found to be in the forward direction with a magnitude of 200 to 400 pounds. This engine satisfactorily completed a cartridge start at altitude and a 10 minute run, during which the engine performed all IFRT transitions for IFRT Engine No. 1, with the relief valve.

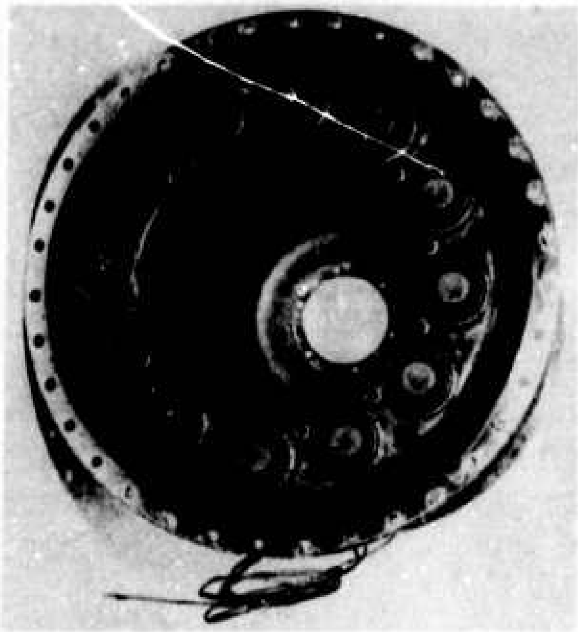
4.8 Preliminary IFRT

Three engines completed IFRT type testing during February 1973. These engines were assembled with the 1/2-inch-diameter relief valve with a 20-psi differential cracking pressure on the thrust-balance cavity, turbine wheel shaft and slinger with increased cooling holes for improved rear bearing cooling, and Mobil Jet II (23699) lubricant in the rear bearing. The remaining engine parts were of standard configuration. The engine serial numbers, the test they received in accordance with QT-8090A, and their endurance run time were as follows:

Serial Number	Test	Run Time
3301	IFRT No. 1	43 minutes
3302	IFRT No. 2	29 minutes
3310	IFRT No. 2 (except handling and maneuvering loads test)	32 minutes

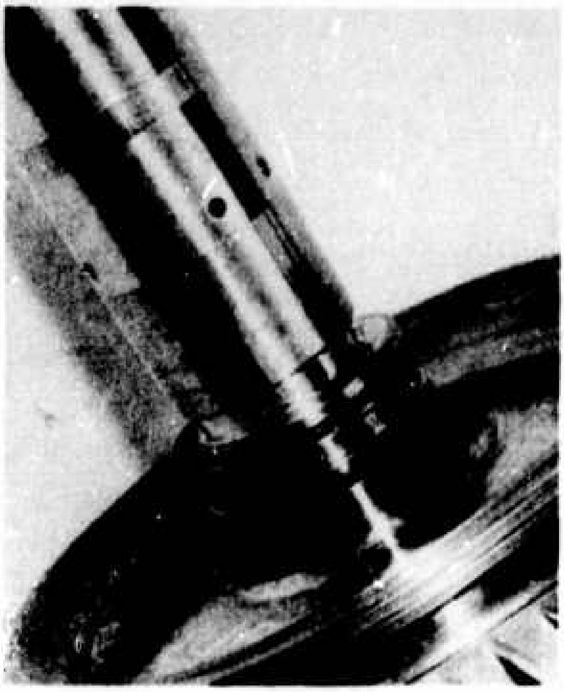
4.8.1 Engine Serial No. 3301

On February 5, 1973, this engine performed a 4-minute acceptance test in accordance with ATP-8030, Rev. 6, dated January 18, 1973. Then, as required by the IFRT Procedure for engine No. 1, the engine was subjected to a 10-hour cold soak at minus 65°F, starting on February 6, 1973. A cartridge start was made at 20,000-foot, M = 0.38, minus 34°F inlet conditions. The engine was transitioned to Phoenix altitude, M = 0.85, 169°F inlet conditions and operated for a total of 43 minutes before being shut down for bearing temperature rise. This rise was due to depletion of available lubricant oil (MIL-L-23699). The 43 minutes of run time is considered as "run to destruction." As can be observed on Figures 52 through 57, the examination after test revealed the condition of the engine hardware to be excellent. Figure 58 shows the recordings, and Figure 59 presents the thrust of the engine during this test.

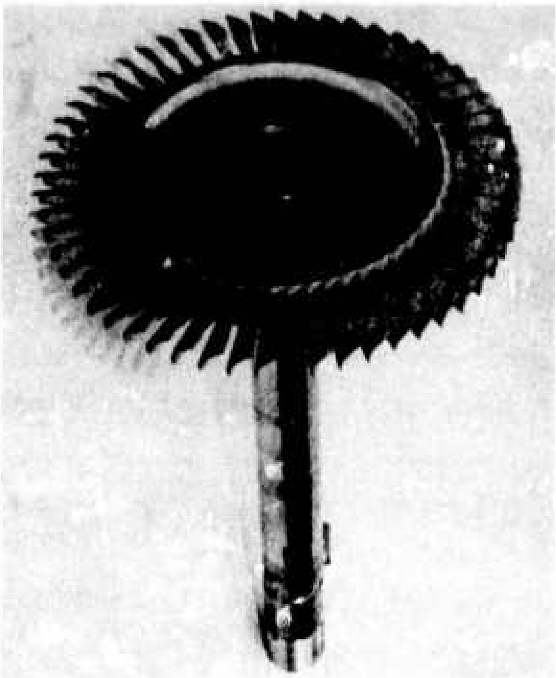


COMBUSTOR NOZZLE (P47043-11)
ASSEMBLY, PART 3740292

COMBUSTOR NOZZLE ASSEMBLY (P47043-10)
PART 3740292

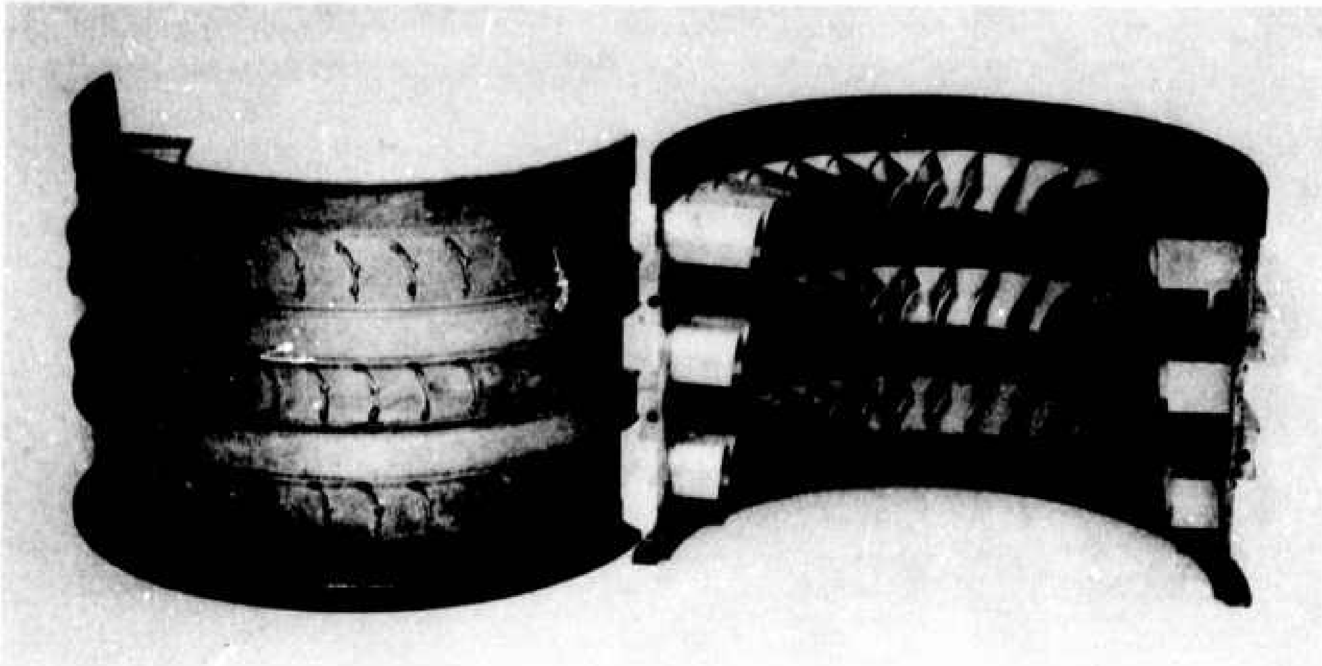


TURBINE WHEEL (P47043-3)
PART 3740283-1



TURBINE WHEEL ASSEMBLY (P47043-2)
PART 3740283-1

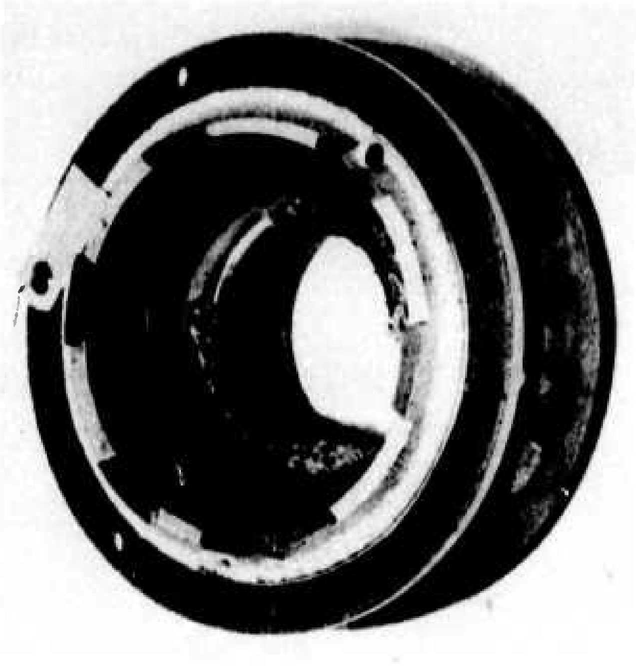
Figure 52. Post-Endurance Test Parts
(Engine Serial No. 3301)



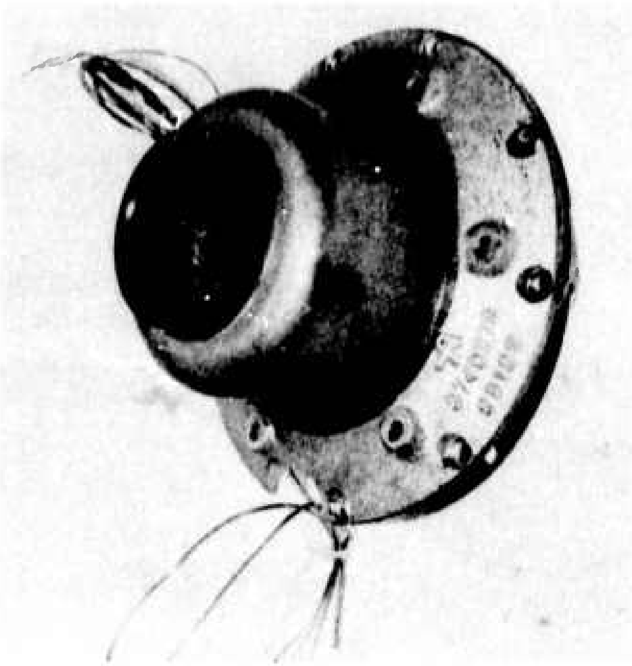
COMPRESSOR HOUSING (P47043-15)
PART 3740270

COMPRESSOR HOUSING (P47043-12)
PART 3740270

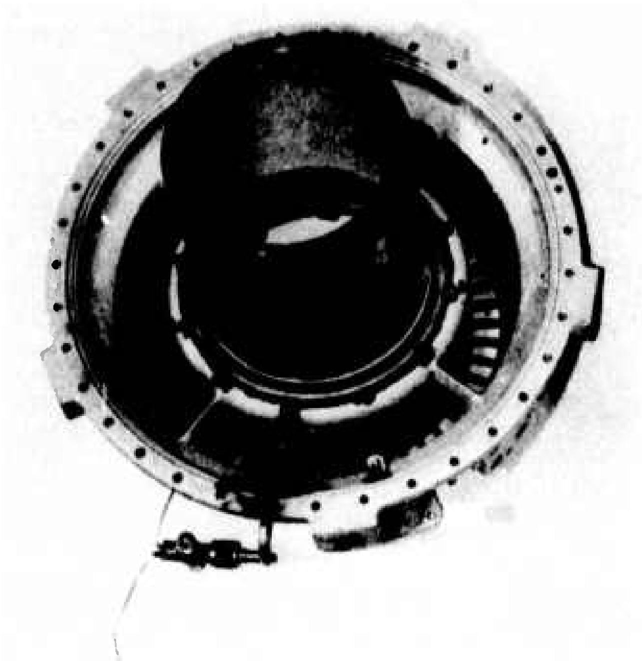
Figure 53. Post-Endurance Test Parts
(Engine Serial No. 3301)



REAR BEARING CARRIER (P47043-30)
PART 3740409

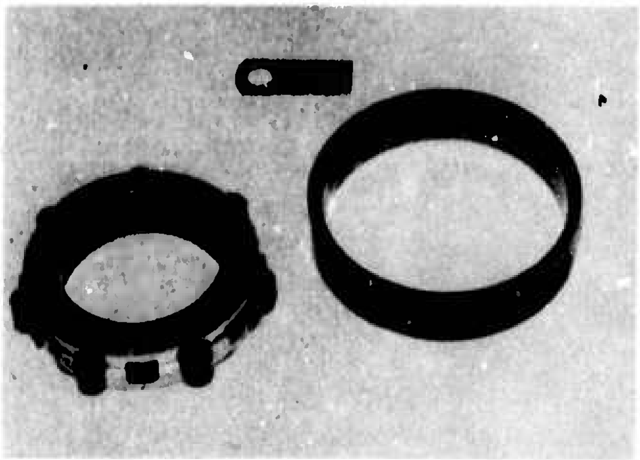


FRONT BEARING CARRIER ASSEMBLY (P47043-29)
PART 3740408



MIDFRAME ASSEMBLY (P47043-17)
3740406

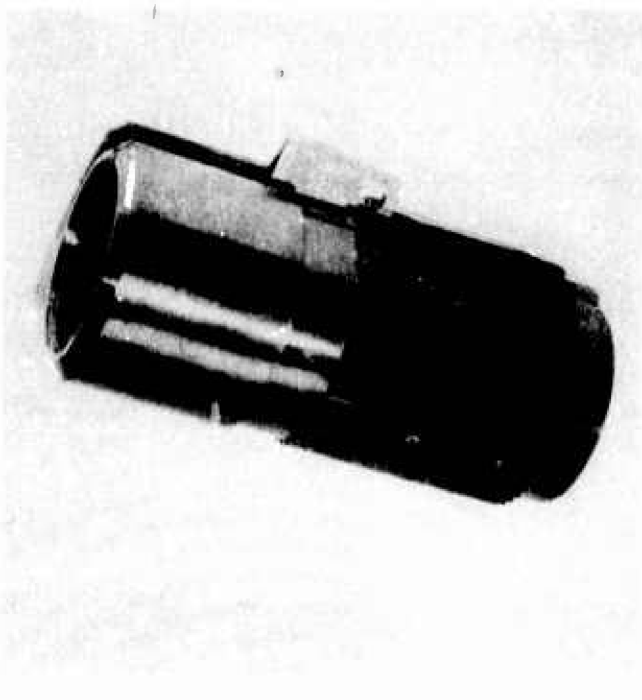
Figure 54. Post-Endurance Test Parts
(Engine Serial No. 3301)



ROLLER BEARING (P47043-21)
PART 358723-2

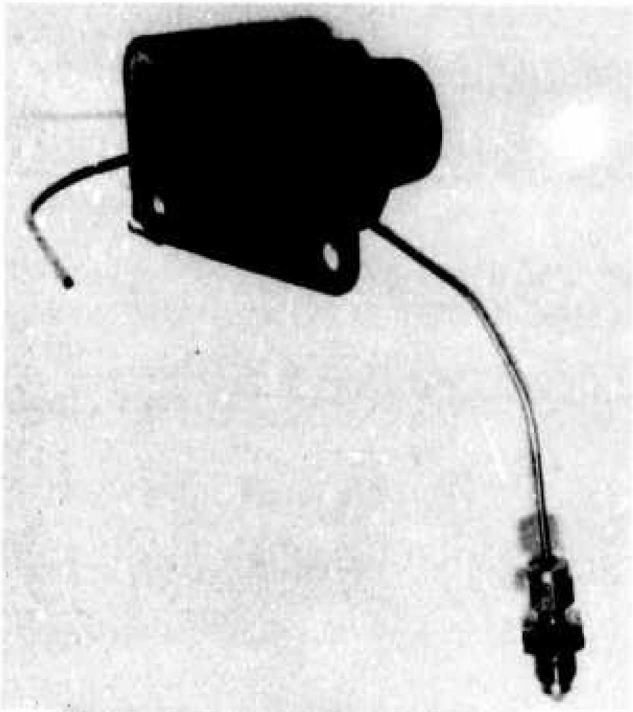
BALL BEARING (P47043-22)
PART 3740290-1

REAR OIL SLINGER (P47043-23)
PART 3740468

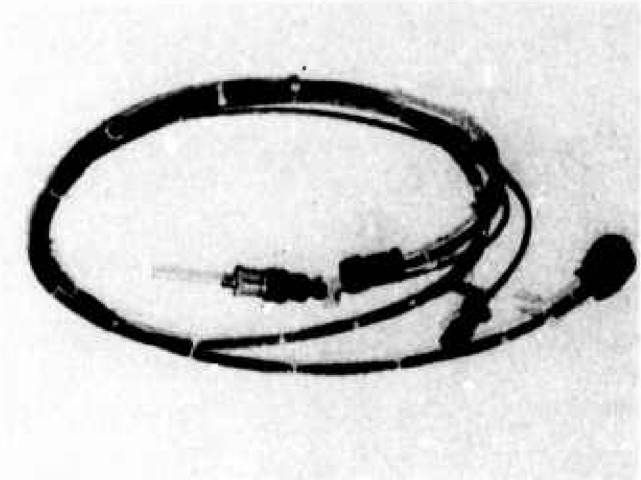


GEARSHAFT (P47043-4)
PART 3740394

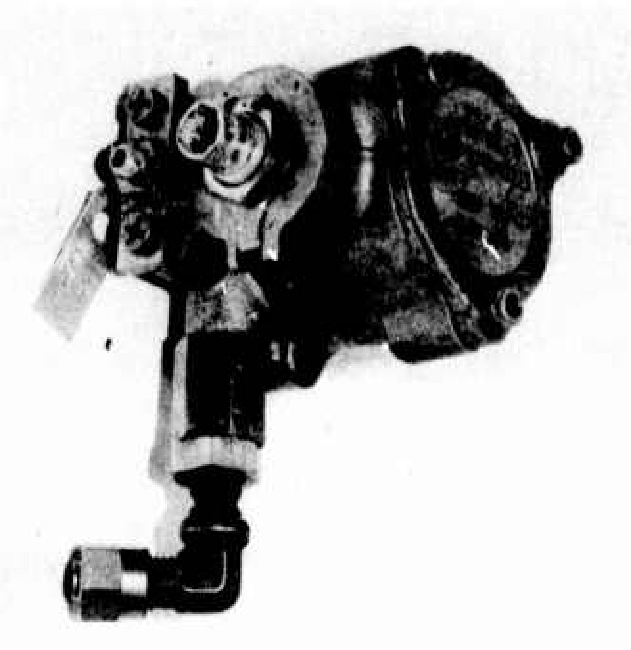
Figure 55. Post-Endurance Test Parts
(Engine Serial No. 3301)



RELIEF VALVE (P47043-27)
PART 771-612-9301



CONTROL WIRING HARNESS (P47043-20)
AND T_{T2} SENSOR
PART 3740458

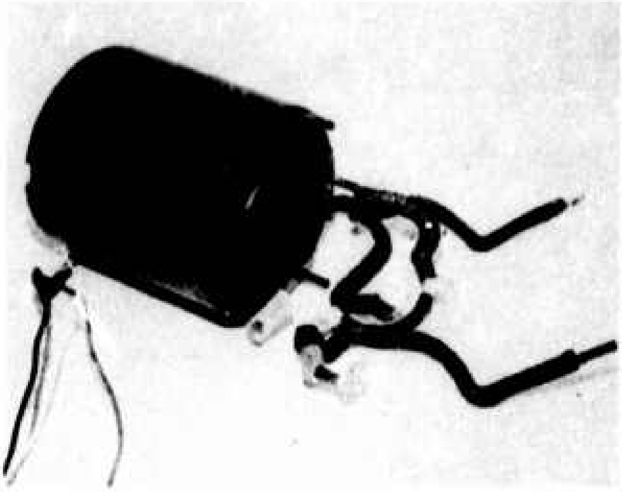


PRESSURE REGULATOR (P47043-19)
PART 3740427

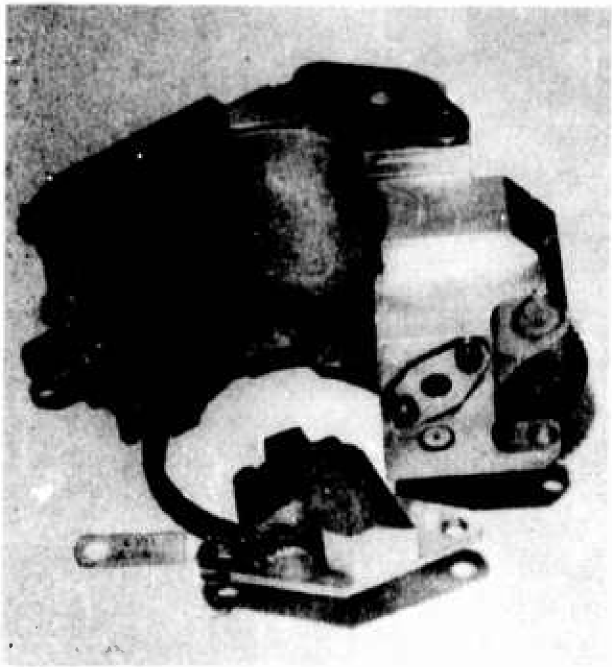
Figure 56. Post-Endurance Test Parts
(Engine Serial No. 3301)

MP-37362

STARTER (P47043-8)
PART 3505055



ALTERNATOR ASSEMBLY (P47043-18)
PART 2045042-2-1

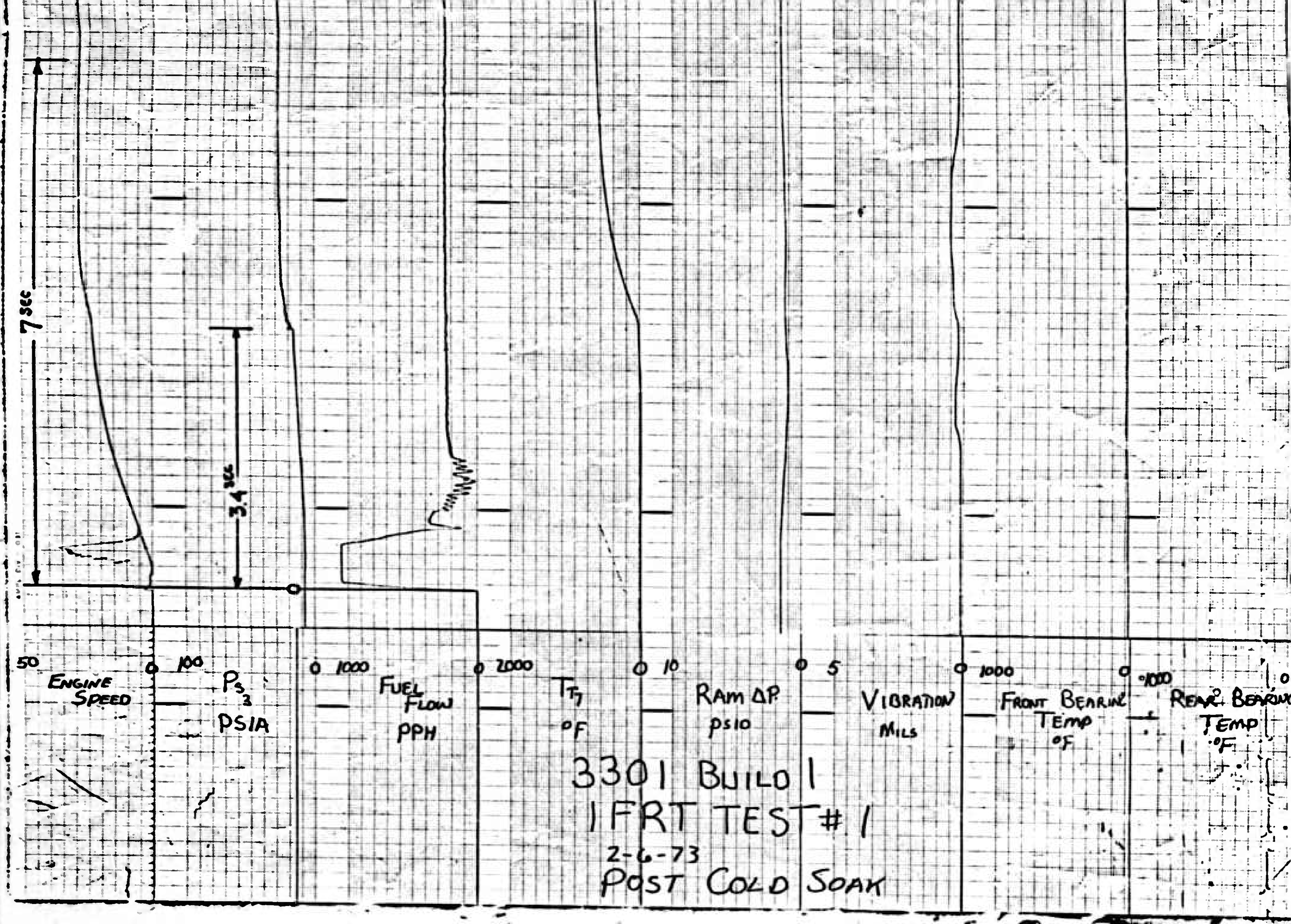


FUEL CONTROL ASSEMBLY (P47043-6)
PART 3740425

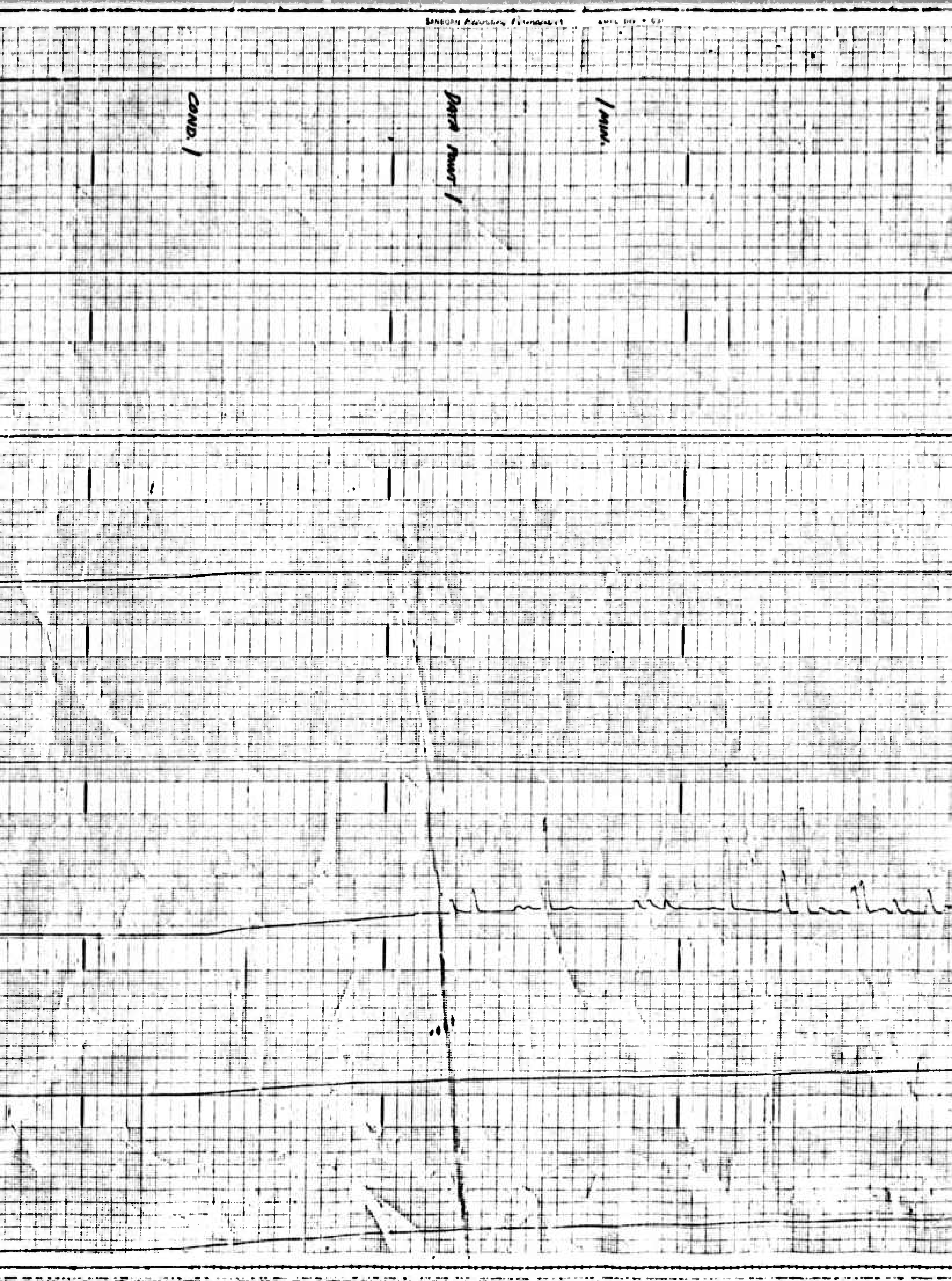
POWER CONDITIONING UNIT (P47043-7)
PART 3740463-1

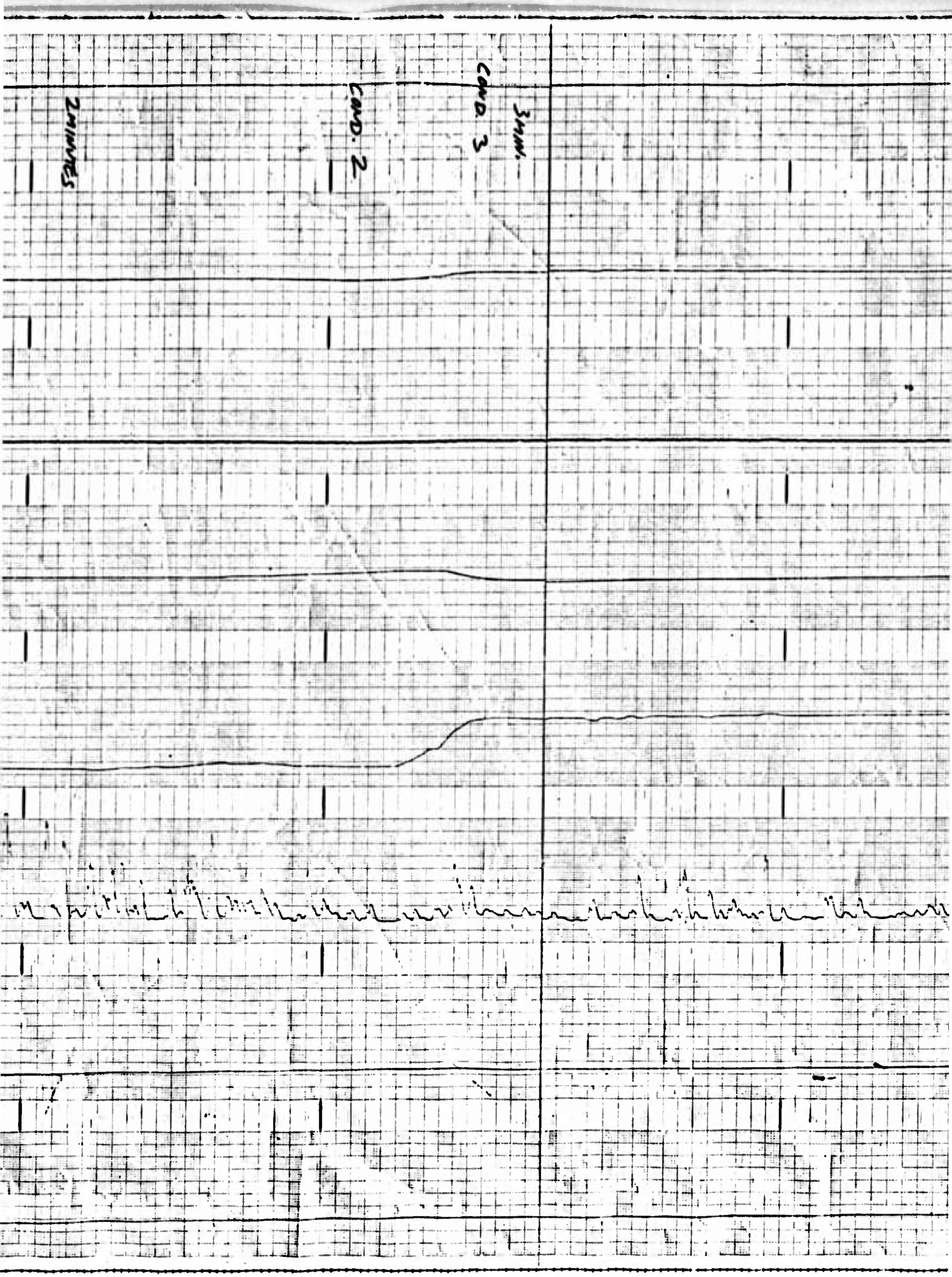
Figure 57. Post-Endurance Test Parts
(Engine Serial No. 3301)

MP-37363

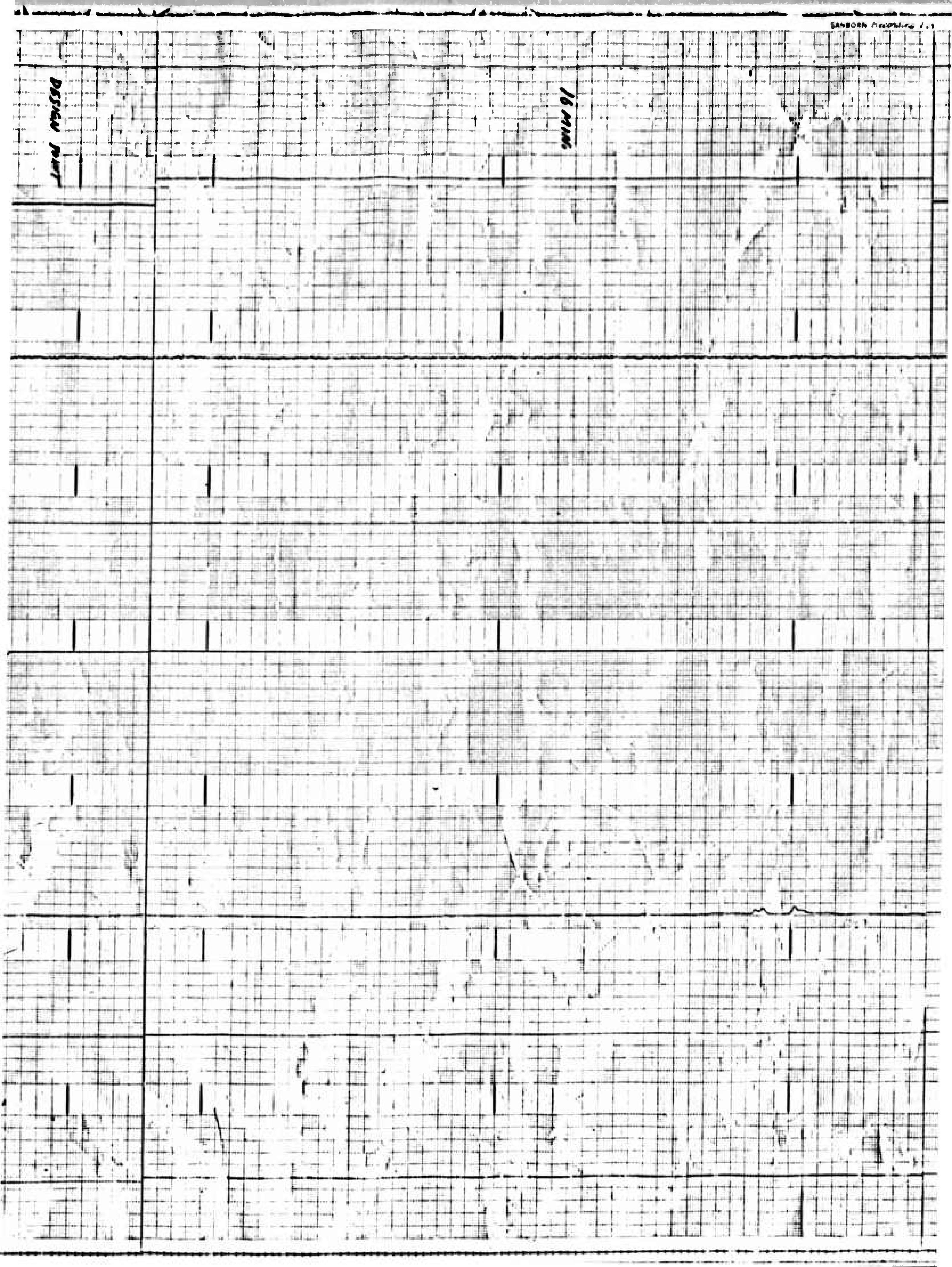


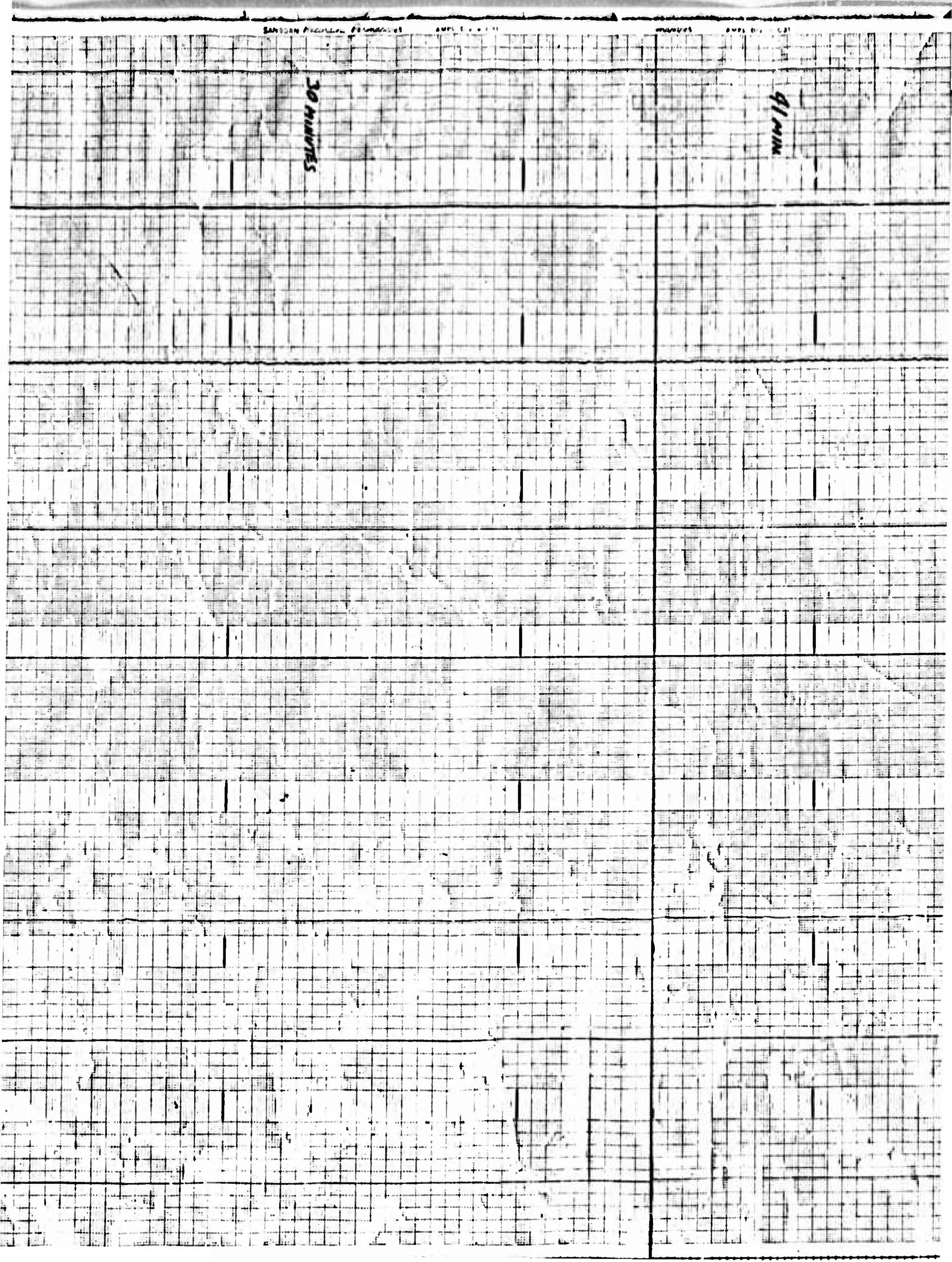
7 sec
3.4 sec
50
0
100
Engine Speed
P_{S_3} PSIA
0 1000
Fuel Flow PPH
0 2000
T_7 °F
0 10
Ram ΔP psid
0 5
Vibration Mils
0 1000
Front Bearing Temp °F
0 1000
Rear Bearing Temp °F
3301 Build 1
IFRT Test #1
2-6-73
Post Cold Soak


COND. 1
DATA POINT 1
1 MIN.


2 MINUTES
COND. 2
COND. 3
3 MIN.

DATA POINT 3
10 MIN.


SANBORN
DESIGN PART
16 MIN


30 MINUTES
91 MIN

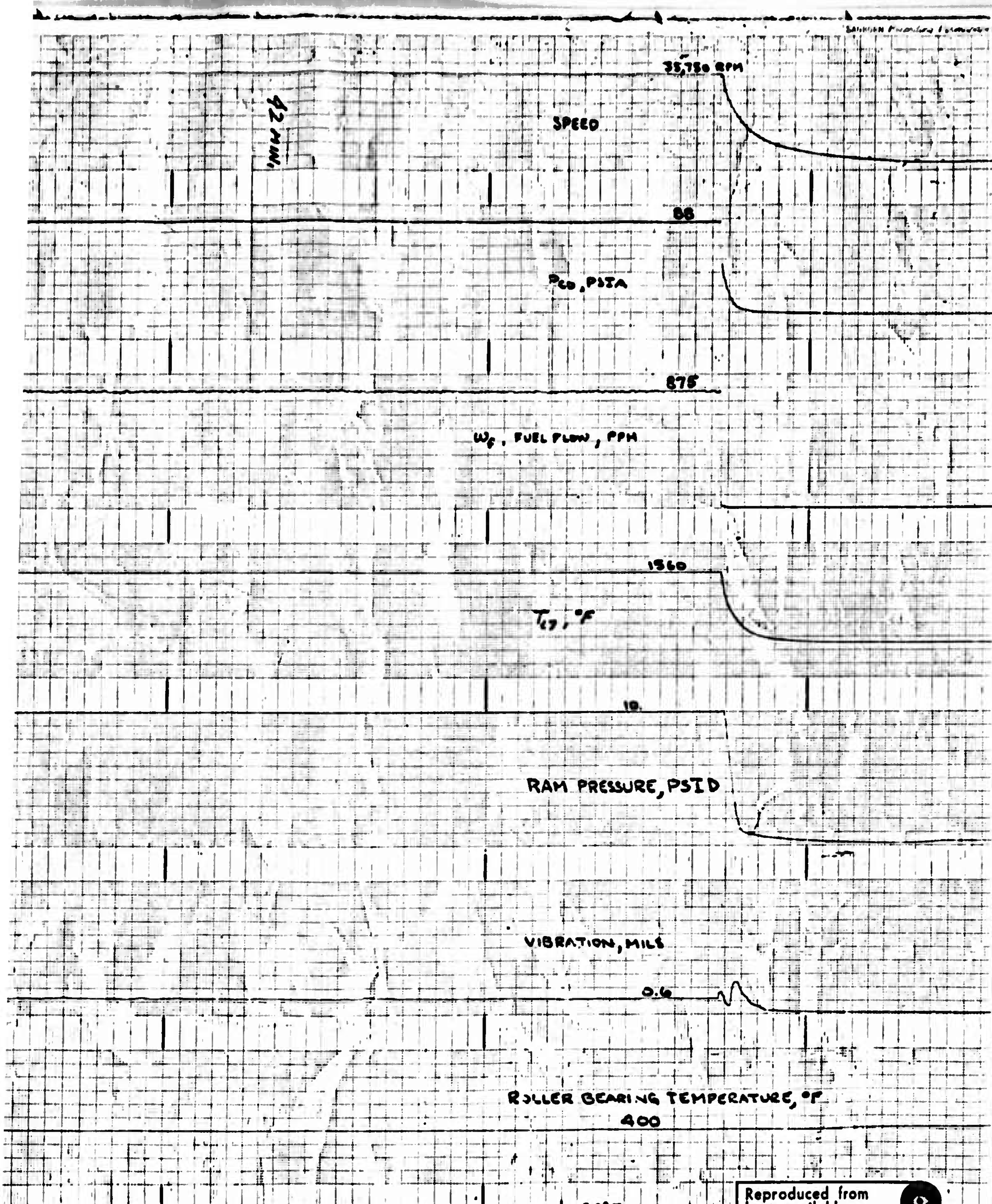
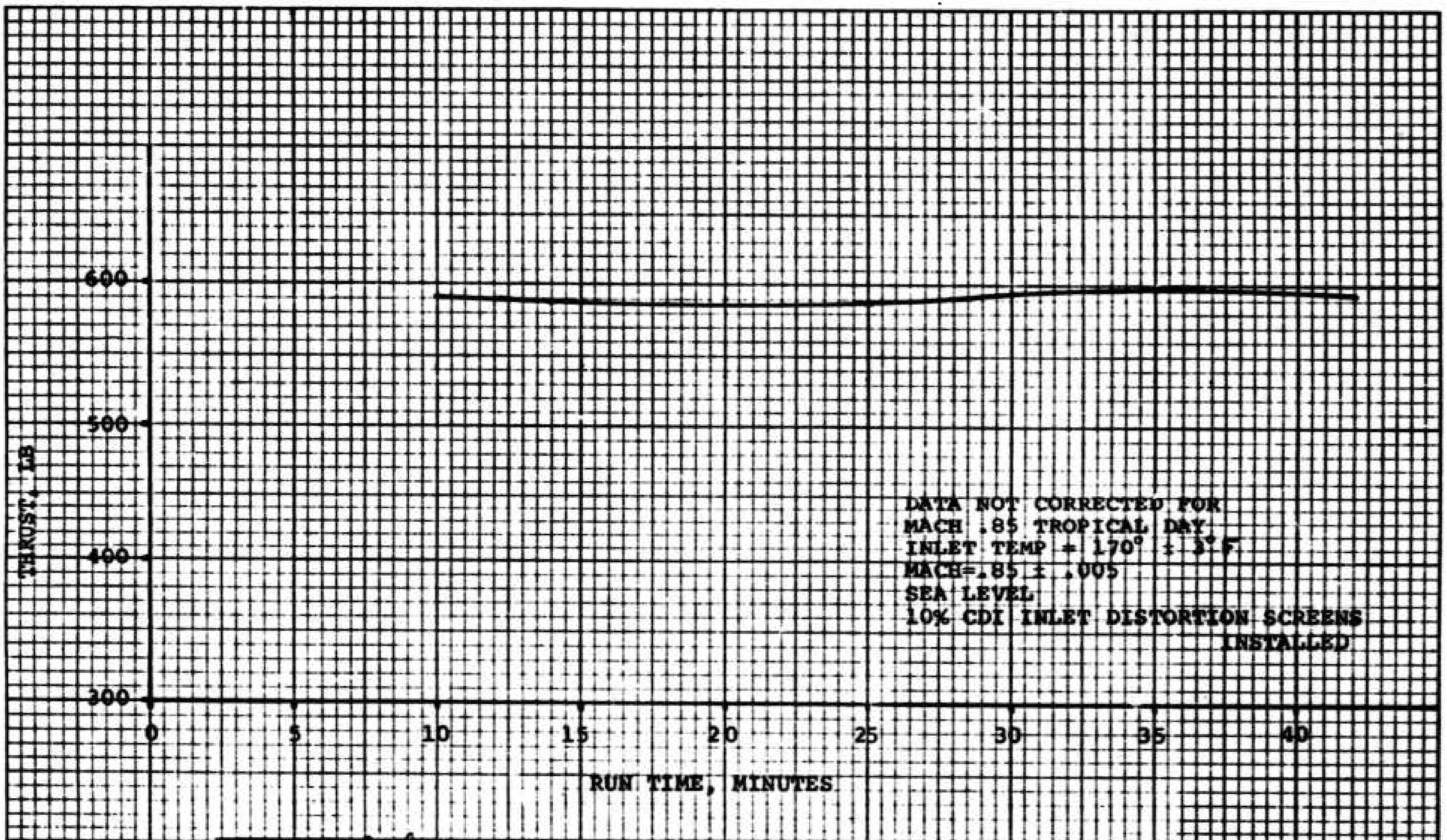


Figure 58. IFRT Endurance XJ401-GA-400 (Engine Serial No. 3301)



CALCULATED BY		2/14/73	XJ401-GA-400 TURBOJET ENGINE SERIAL NO. 3301 2/6/73 COLD SOAK ENDURANCE TEST	Figure 59
TRACED BY				
CHECKED BY				
APPROVED BY		2/73	AIRESEARCH MANUFACTURING COMPANY	C85962
UNIT NO.				

4.8.2 Engine Serial No. 3302

A 4-minute acceptance test was performed on February 7, 1973, in accordance with ATP-8030, Rev. 6. This engine was then tested on February 7, 1973, in accordance with the requirements of IFRT engine No. 2 in QT-8090A.

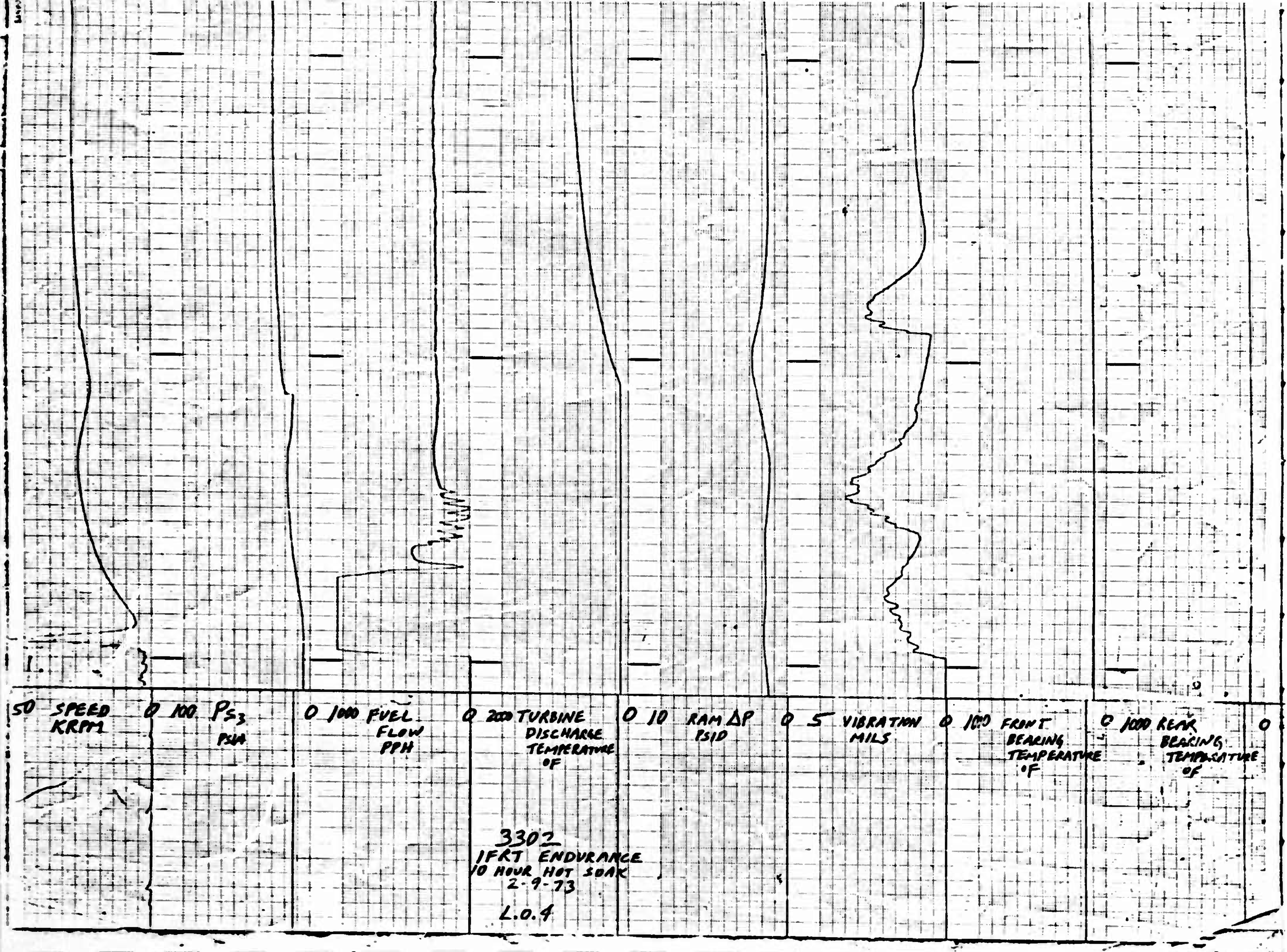
The engine was subjected to the handling and maneuvering loads test followed by a 10-hour hot soak at plus 160°F. A cartridge start at 20,000-foot, M = 0.60, 60°F inlet conditions was conducted. Then a 29-minute endurance test during which the engine performed transitions to Phoenix altitude, M = 0.85, 169°F inlet conditions. The engine was shut down because of a sudden rise in rear bearing temperature due to depletion of available lubricant (MIL-L-23699). The condition of the hardware after the test was generally excellent. One stator vane burn-through was observed. Figure 60 shows the recordings, and Figure 61 presents the engine thrust information obtained during this run.

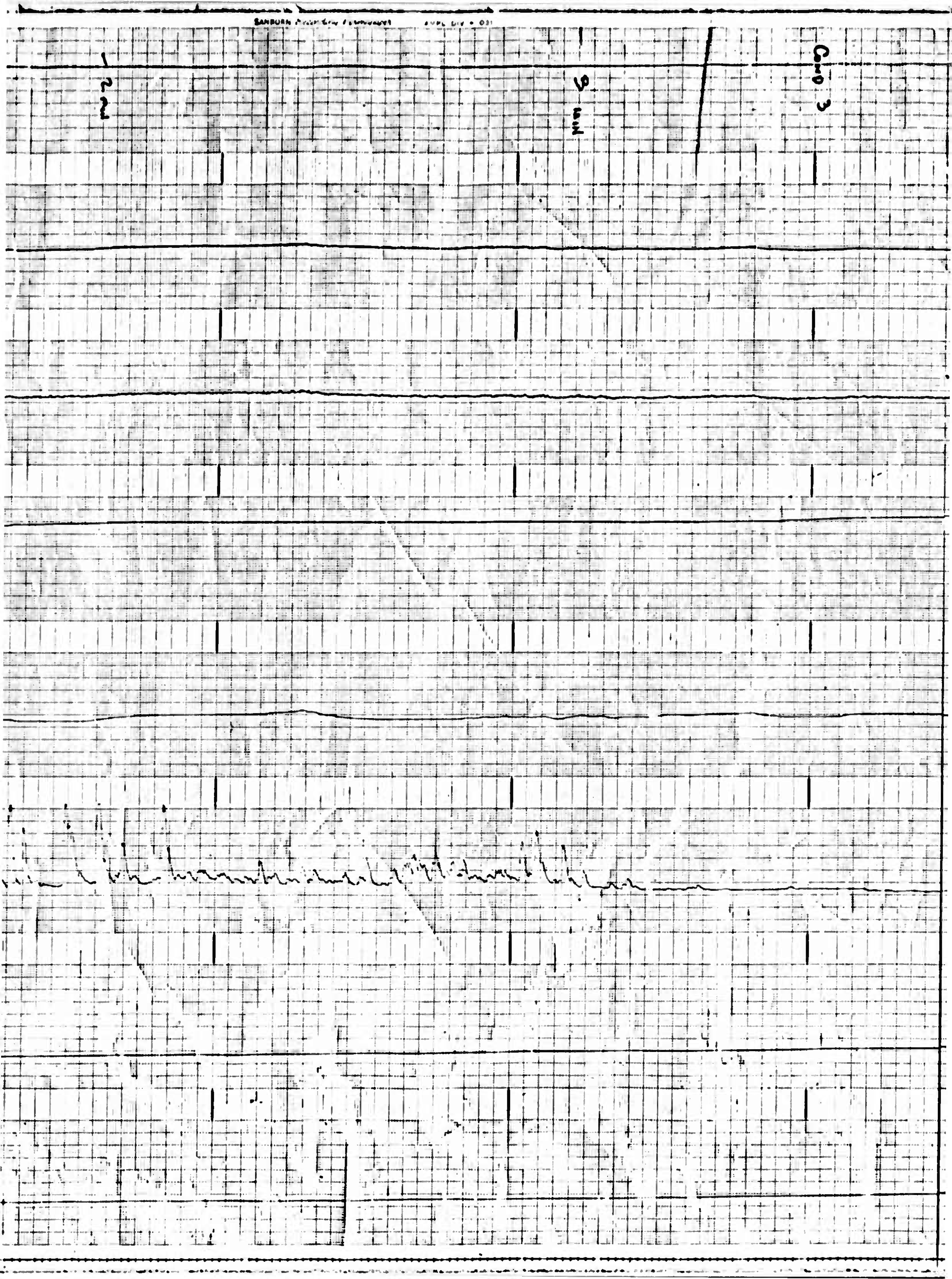
4.8.3 Engine Serial No. 3310

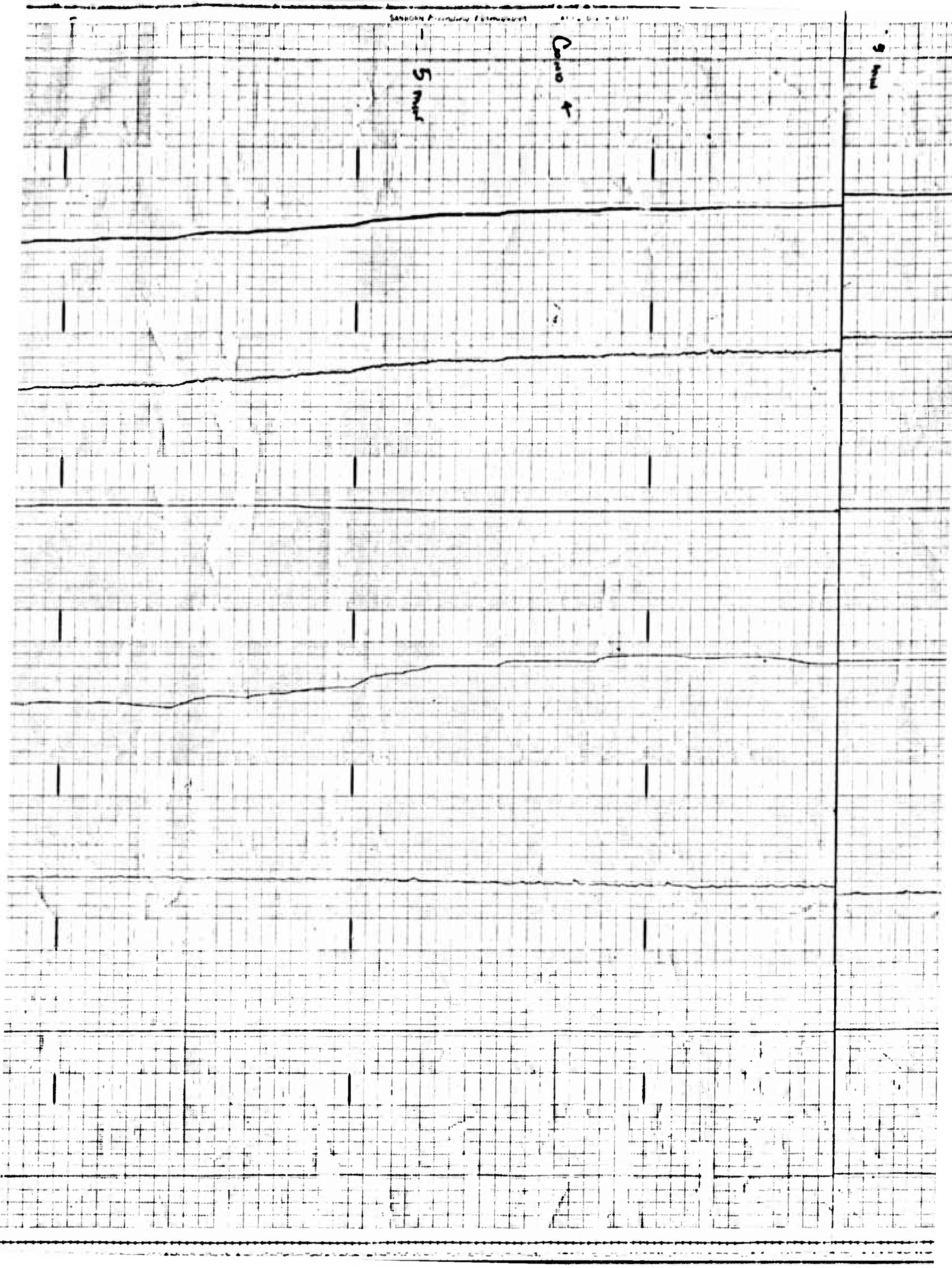
This engine was tested to evaluate the quantity of Mobil Jet II lubricant available to the rear engine bearing. The testing was conducted on February 1 and 2, 1973. The test consisted of a standard acceptance test followed by a 10-hour, 160°F soak and a cartridge start at 20,000 foot, M = 0.6, 60°F inlet conditions. Subsequently, the engine completed a 32-minute endurance test. The after-test condition of the engine bearings and other lubricated components was very good, indicating that an adequate quantity of lubricant was available during the test.

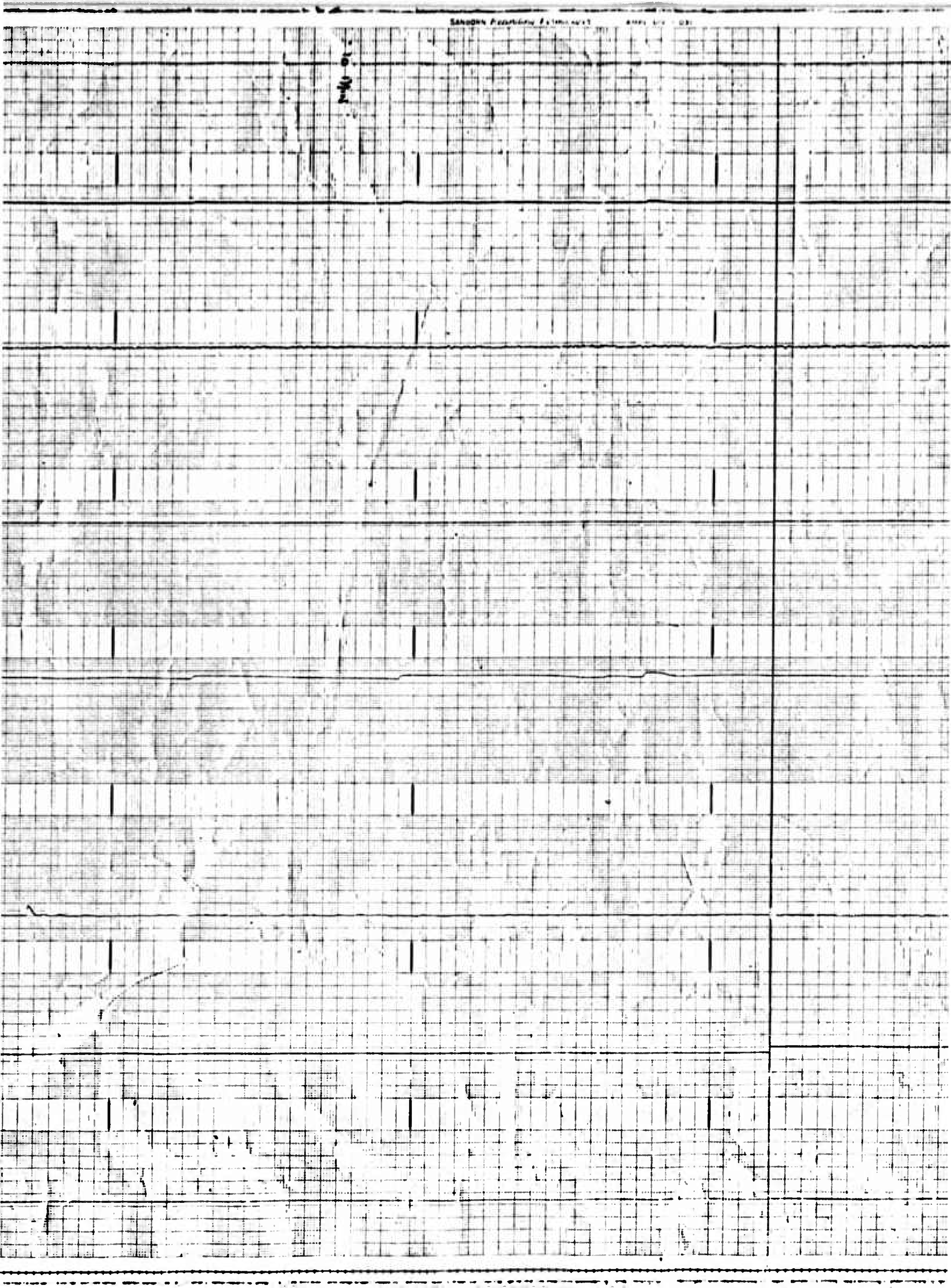
4.9 Diffuser-Combustor Improvement Program

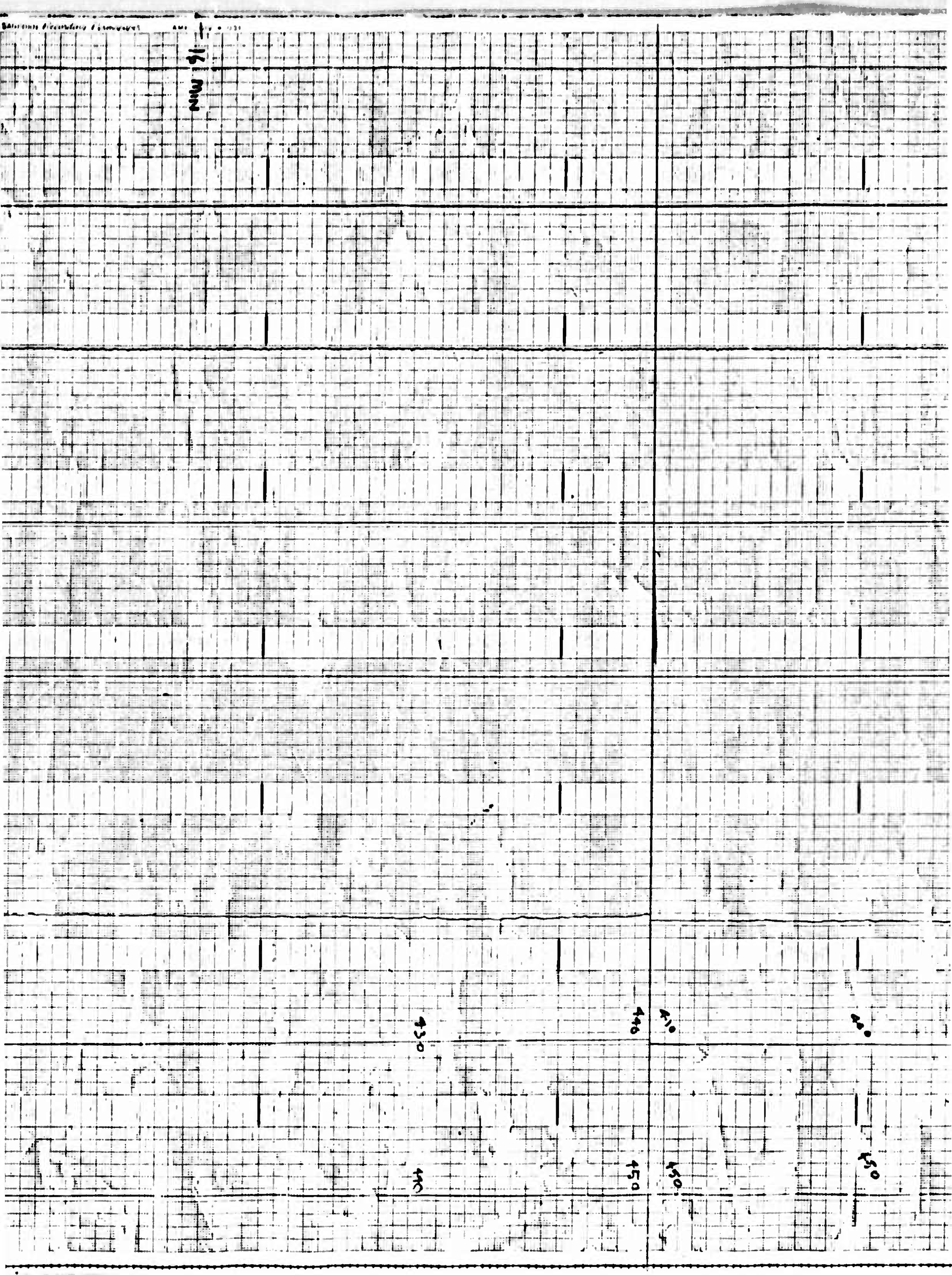
The purpose of these tests was to evaluate the diffuser-combustor system effect upon turbine inlet temperature distribution. During acceptance tests started but not completed in February 1973, nozzle


50 SPEED KRPM 0
100 P_{S3} PSIA 0
1000 FUEL FLOW PPH 0
2000 TURBINE DISCHARGE TEMPERATURE °F 0
10 RAM ΔP PSID 0
5 VIBRATION MILS 0
1000 FRONT BEARING TEMPERATURE °F 0
1000 REAR BEARING TEMPERATURE °F 0
3302
IFRT ENDURANCE
10 HOUR HOT SOAK
2-9-73
L.0.4

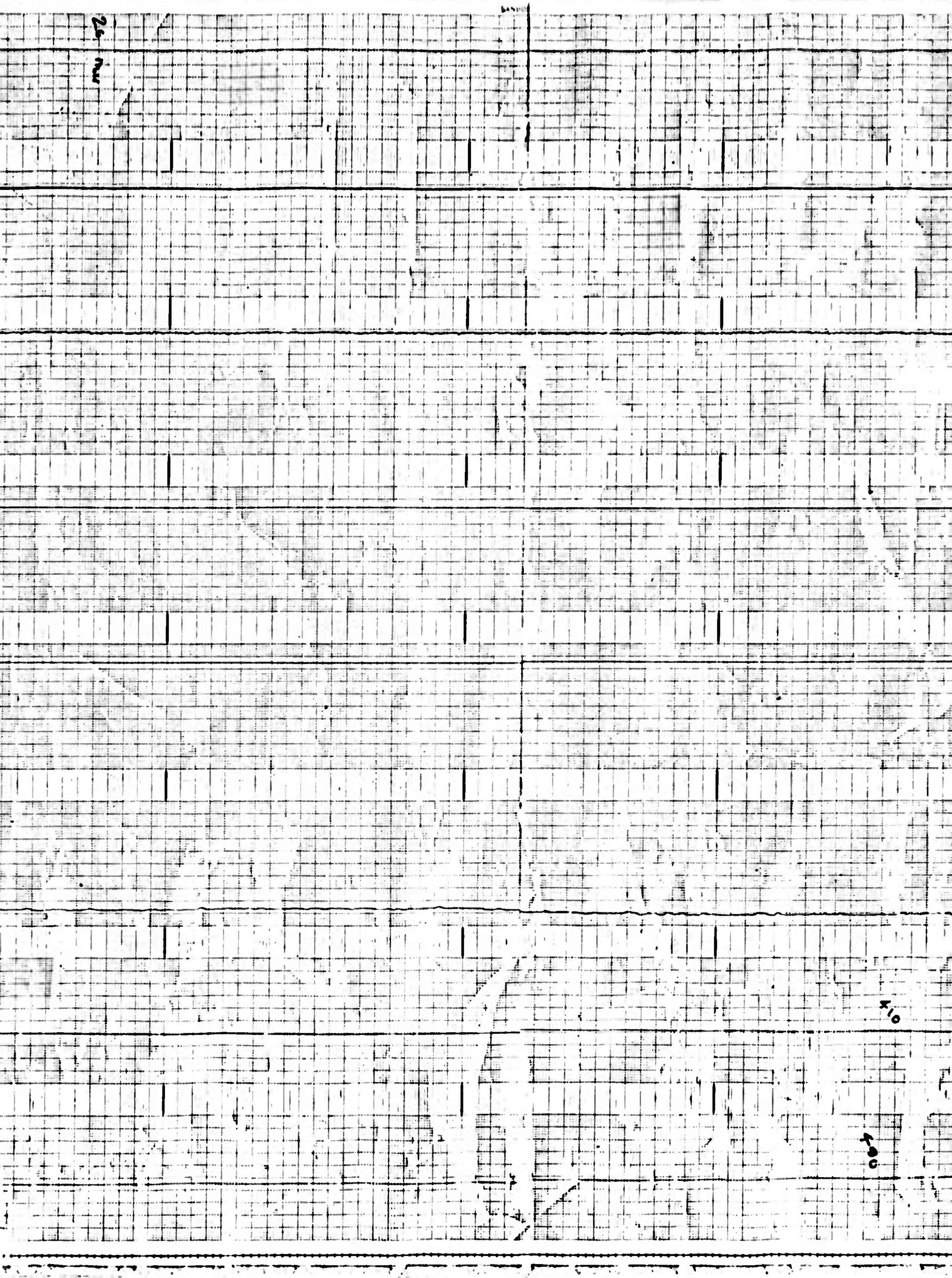

SANBORN
2nd
9 min
Comp 3


SANBORN
5 mg


SANBORN



16 MIN
430
410
400
450
450
450


x10

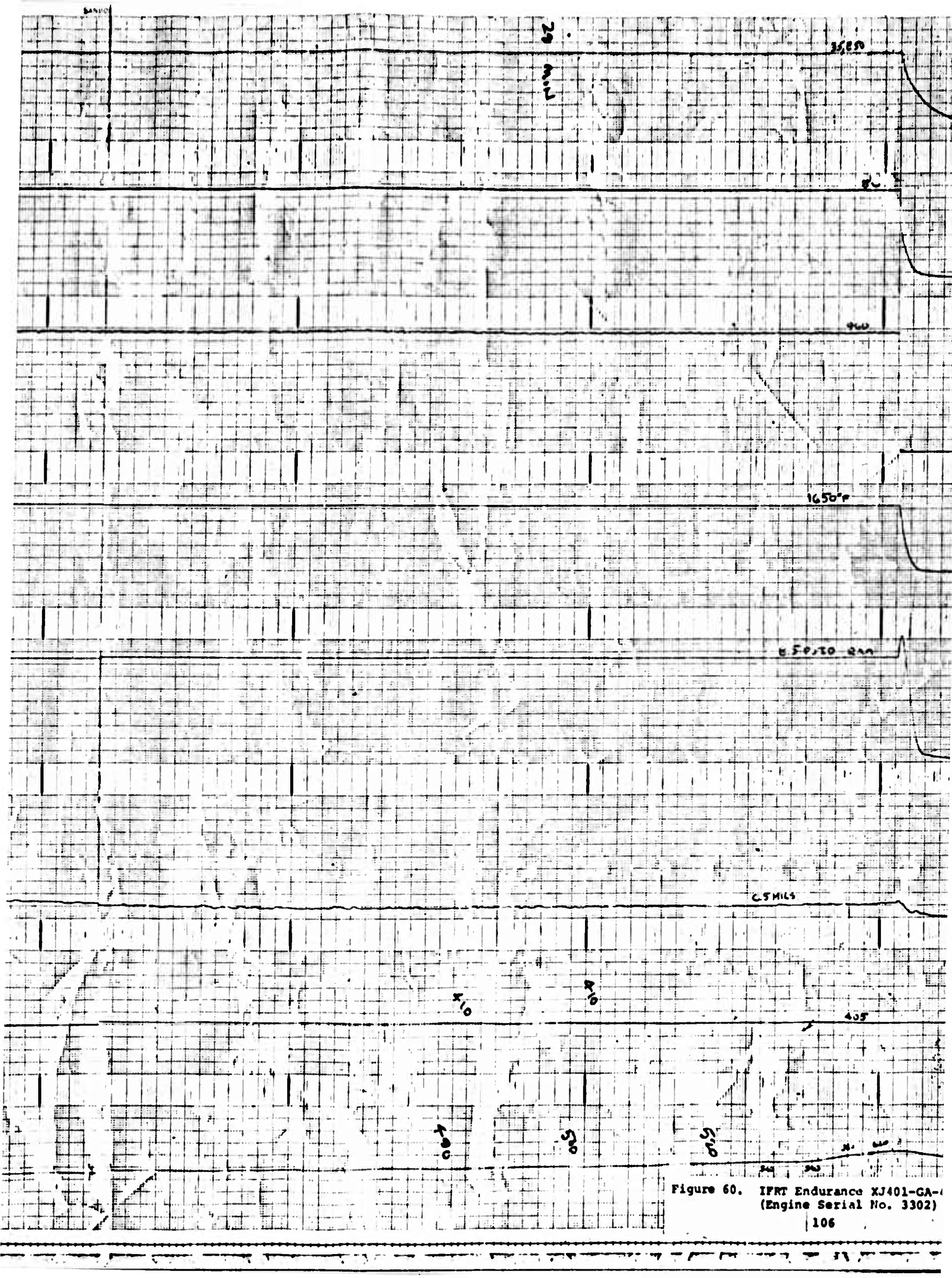
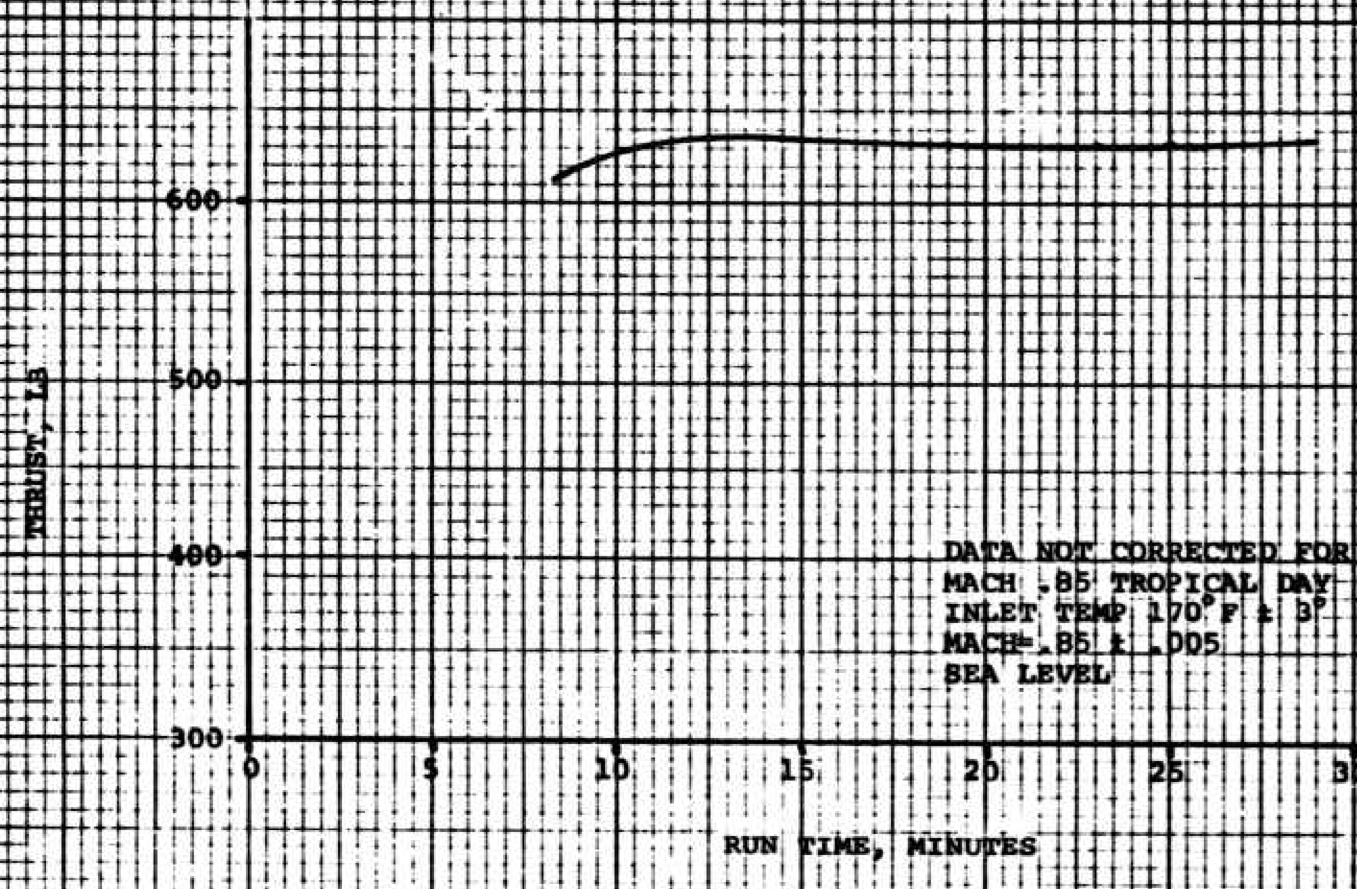


Figure 60. IFRT Endurance XJ401-GA-(
(Engine Serial No. 3302)



CALCULATED BY	RJF	2/14/73	XJ401-GA-400 TURBOJET ENGINE SERIAL NO. 3302 2/9/73 HOT SOAK ENDURANCE TEST
TRACED BY			
CHECKED BY			
APPROVED BY	[illegible]	2/22	
UNIT NO.			AIRESEARCH MANUFACTURING COMPANY

Figure 61

C85963

vane distress occurred. Due to this distress, an intensive diffuser-combustor improvement development program was conducted before starting the IFRT.

During this development program, back-to-back testing of a complete engine at full speed without combustion was used to refine the midframe design. A midframe Diffuser Part 3740406 used during the aborted acceptance testing was the reference design (see Figure 54). The improved diffuser design, Part 3740479, developed through the back-to-back rig testing is shown in Figure 62. The improved diffuser design is hand-finished smooth from the as-cast surface in order to provide consistent results, and incorporates radial poles in line with the fuel inlets. These poles are located in circumferential positions where there were no struts. Partial trip tubes to provide a uniform presentation of air to the combustor assembly were also incorporated. The pressure drop for this improved configuration was comparable to that of the reference design.

The combustor design was also improved, based upon a series of combustor rig tests with use of engine hardware. The original design Combustor, Part 3740293-1, had four rows of outer-wall dilution holes and three rows of inner-wall dilution holes, with each row containing 18 holes. The holes were all of the same diameter, pierced flat, with no flare. The improved Combustor, Part 3740478-1, utilized a different hole pattern with four rows of flared holes on the inner and outer walls. The holes in the first two rows were smaller in diameter, with 24 holes per row, and the two downstream rows had 12 holes per row. The new hole pattern and the flaring of the holes were intended to provide better mixing of the products of combustion with dilution air.

The improved combustor and midframe diffuser were assembled into engines and, prior to acceptance testing, subjected to a green run. This green run was conducted with the use of an exhaust nozzle instrumented with 33 equally spaced rows of three thermocouples. The maximum

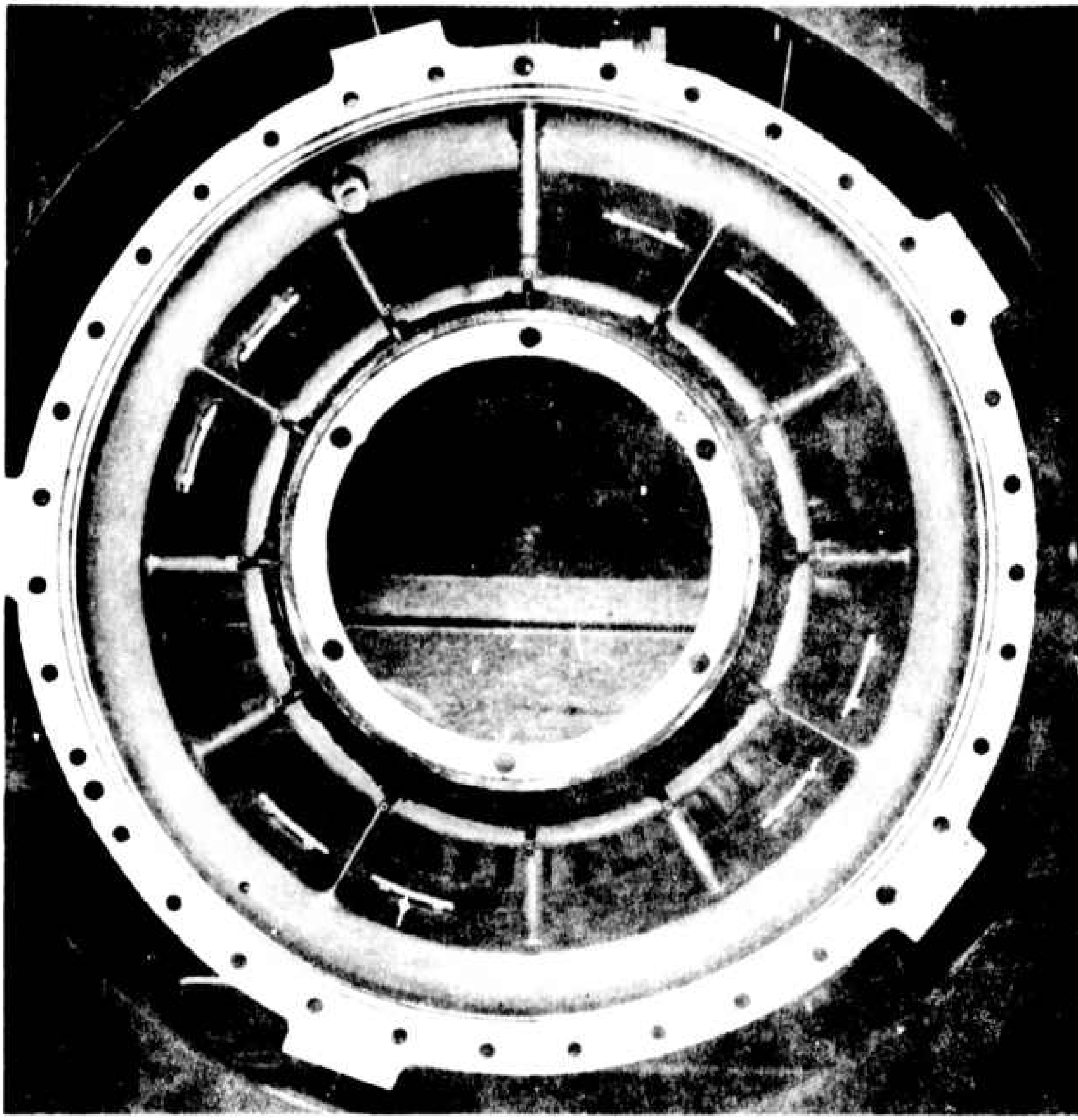


Figure 62. Improved Diffuser Part 3470429.

allowable temperature spread factor (TSF) at a fuel-air ratio of 0.019 was 0.34 as evaluated from the following equation:

$$TSF = \frac{T_4\text{Maximum} - T_4\text{Average}}{T_4\text{ Average} - T_3\text{ Average}}$$

where T_4 = turbine inlet temperature, °F

T_3 = compressor discharge temperature, °F

The green-run TSF results for the IFRT engines are given in Section 6.4.

5.0 INITIAL FLIGHT RATING TEST (IFRT)

5.1 Purpose

The purpose of the test was to demonstrate the capability of the Model XJ401-GA-400 Expendable Turbojet Engine (AiResearch Part 3740300-1) to meet the IFRT requirements of QT-8090A, dated February 5, 1973. This test satisfies the initial flight rating test as described in Paragraph 4.3.2, Part III, of AiResearch Model Specification SC-8029-A, for the Naval Air System Command Model XJ401-GA-400 Engine, Missile, Turbojet.

5.2 Summary

5.2.1 Abstract

The initial flight rating tests were conducted on two engines. The engines and the tests they completed are listed as follows:

IFRT Engine No. 1

- o Green run [to determine temperature spread factor (TSF)]
- o Acceptance (ATP) (Windmill and altitude start, 4 minutes total run)
- o Low-temperature soak (minus 65°F for 10 hours)
- o Altitude start (20,000 feet, cold day)
- o Inlet distortion operation (10 percent CDI screen installed in inlet)
- o Design-point operation (tropical day, sea-level) vibration survey (total run time of 20.5 minutes)
- o Disassembly and inspection

IFRT Engine No. 2

- o Green run [to determine temperature spread factor (TSF)]
- o Acceptance (ATP) (Windmill and altitude start, 4.4 minutes total run)
- o Handling and maneuver loads (17.5 g's)
- o High-temperature soak (160°F for 10 hours)
- o Altitude start (20,000 feet, hot day)
- o Design-point operation (tropical day, sea-level) vibration survey (total run time of 26.2 minutes)
- o Disassembly and inspection

Testing was started on March 30, 1973, and completed on April 7, 1973. A summary listing of the acceptance test data for each engine, corrected to the design point (sea level, Mach 0.85, 90°F ambient temperature), and with a 3.8-kw output, is presented as follows:

TABLE XIV. ACCEPTANCE TEST.

IFRT No.	Net Thrust (Pounds)			TSFC (lb/hr/lb)			Measured Gas Temp. (°F)	
	Spec. (Min)	Engine	Percent *Margin	Spec. (Max)	Engine	Percent *Margin	Spec. (Max)	Engine
1	600	607	+1.2	1.687	1.641	+2.7	1582	1553
2	600	611	+1.8	1.687	1.627	+3.6	1582	1580

A summary listing of the IFRT design-point performance data at 16 minutes of run time is presented in Table XV. The data is corrected to the design point (sea level, Mach 0.85, 90°F ambient temperature).

---

*Percent margin relative to Model Specification requirements. Positive margin indicates higher thrust or lower TSFC than required.

TABLE XV. IFRT TEST.

IFRT No.	Net Thrust (Pounds)			TSFC (lb/hr/lb)			Measured Gas Temp. (°F)	
	Spec. (Min)	Corr.	Percent *Margin	Spec. (Max)	Corr.	Percent *Margin	Spec. (Max)	Corr.
1	600	619	+3.2	1.687	1.631	+3.3	1612	1587
2**	600	578	-3.7	1.687	1.602	+5.0	1612	1418

*Percent margin relative to Model Specification requirements. Positive margin indicates higher thrust or lower TSFC than required.

**Demonstrated performance shown is discussed in Paragraph 5.8.4.

5.2.2 Conclusions

From the test results it is concluded that the Model XJ401-GA-400 Expendable Turbojet Engine has met the requirements of the initial flight rating tests for the Harpoon Missile, as specified in QT-8090A.

This report is the Final Test Report and also the Final Report for the contract.

5.2.3 Recommendations

It is recommended that the tests reported herein be accepted by the Naval Air System Command as verification of the capability of the Model XJ401-GA-400 Expendable Turbojet Engine to meet the requirements of AiResearch Model Specification SC-8029A.

5.3 References

- AiResearch Model Specification SC-8029-A, Engine, Missile, Turbojet, for Naval Air Systems Command Model No. XJ401-GA-400, AiResearch Part 3740300-1, 30 November 1972.

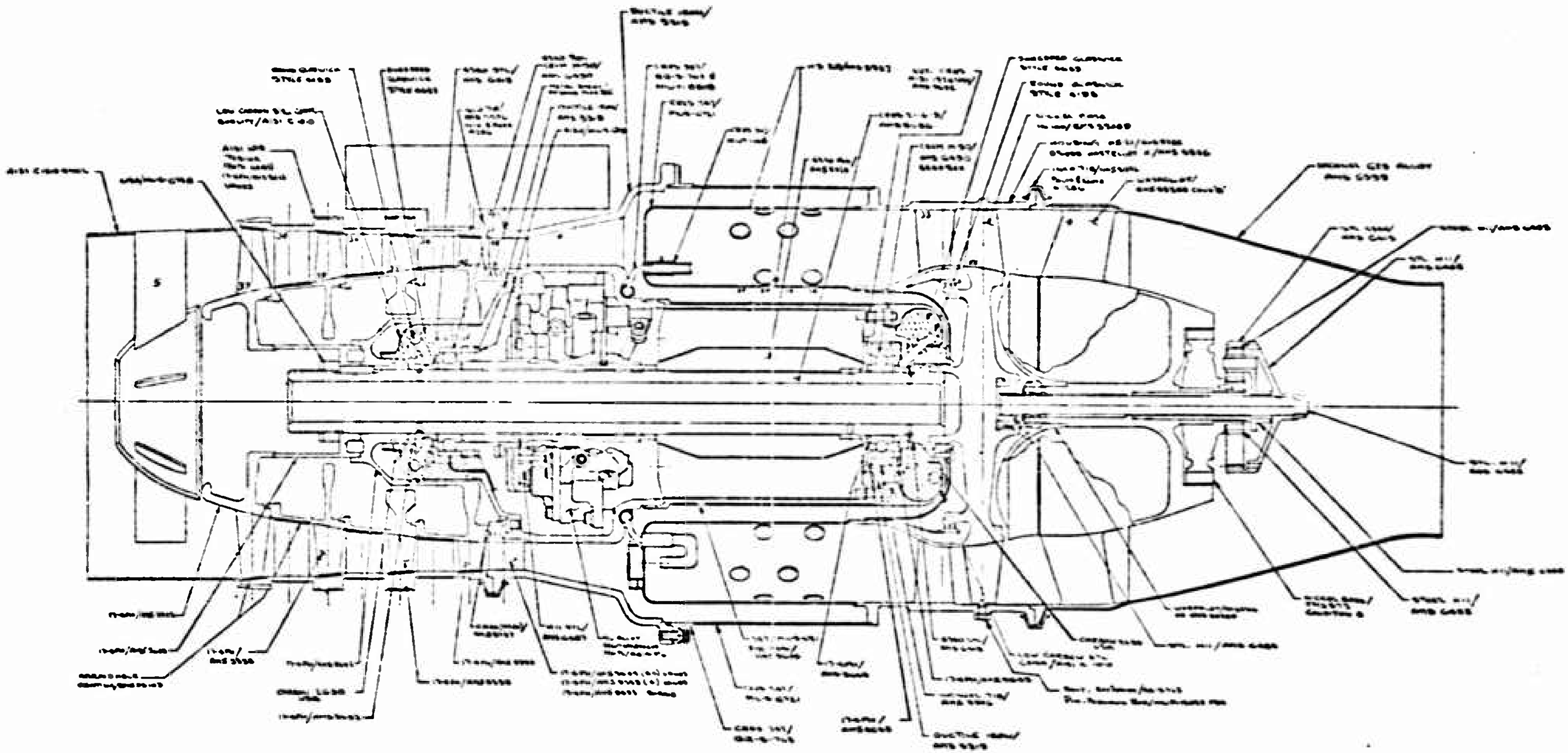
- AiResearch Acceptance Test Procedure QT-8030, Rev. 6, for the Naval Air Systems Command Model XJ401-GA-400 Expendable Turbojet Engine, January 18, 1973.

- AiResearch Initial Flight Rating Test Procedure QT-8090A, for Naval Air Systems Command Model XJ401-GA-400 Expendable Turbojet Engine, February 5, 1973.

5.4 Engine Description

The type and model designation of this turbojet engine is XJ401-GA-400 as assigned by the Naval Air Systems Command, U.S. Navy. The engine has a circumferential inlet. The engine comprises a four-stage axial compressor driven by a common rotor shaft connected to a single-stage axial turbine. Compressor discharge air is directed through an in-line annular air-blast atomization combustor. Combustion gases pass through the turbine and are discharged axially through an engine exhaust cone. A cross-section of the engine is shown in Figure 63.

The engine control system provides for automatic control of the engine from initiation of the start sequence through acceleration to maximum speed and power throughout the engine operating envelope. This schedule is used to accelerate the engine to maximum power and to maintain the maximum power setting without requiring an external signal input. The control system furnished with the engine consists of a constant-displacement fuel pump, a fuel metering section, and an airframe-mounted electronic computer assembly.



XJ401-GA-400

Figure 63. Cross-Section View of XJ401-GA-400.

The engine is started by a solid-propellant starter and a pyroflare, both of which are ignited by electrical squibs. The flaming products of the pyroflare ignite the fuel-air mixture in the combustor, and the combusted products drive the turbine. The fuel control schedules fuel automatically during starting, acceleration, and operation.

The engine rotor shaft is simply supported on two antifriction bearings. Each of the bearings is lubricated by a self-contained oil-wick lubrication system.

The engine is capable of furnishing a supply of dc electrical power.

Engine components are described in detail in Section 3.0, Paragraph 3.2.

5.4.1 Test Engine Identification

Photographs of the engine attached to its mounting plate, showing the right and left side in a front and rear oblique view, are shown in Figures 64 through 67.

The engine assembly traveler and engine build runout sheet, are contained in Section 6.1, and component inspection records for both engines are contained in Section 6.2 of this report. The engine parts for both engines were placed in the Government Bond Room after the post-test disassembly and inspection.

5.5 Facility Description

5.5.1 Test Setup

The acceptance tests and all initial flight rating tests except the handling and maneuvering loads test were conducted in the AiResearch

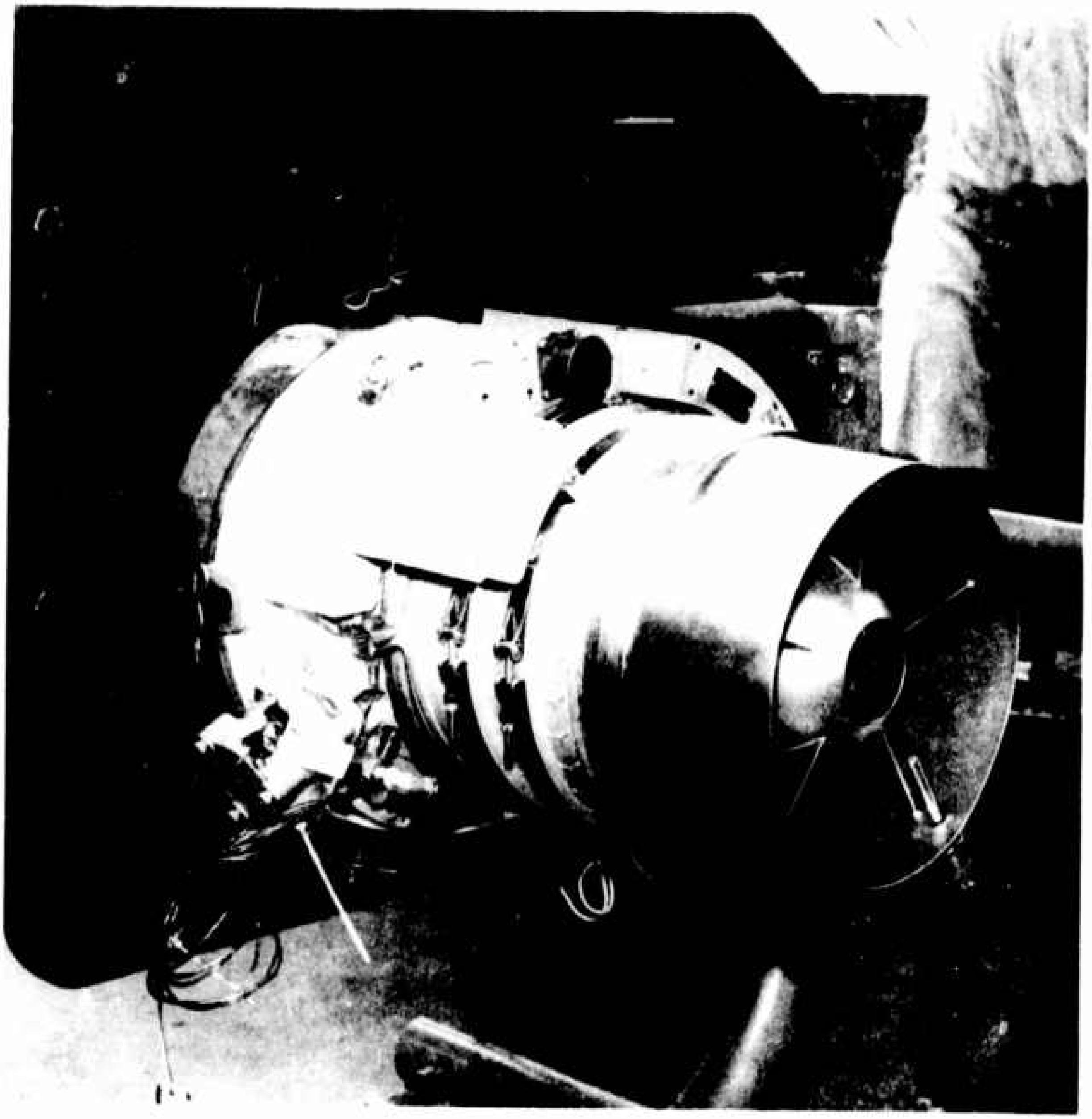


Figure 64. IFRT Engine Model XJ401-GA-400 (Right Front Oblique View).

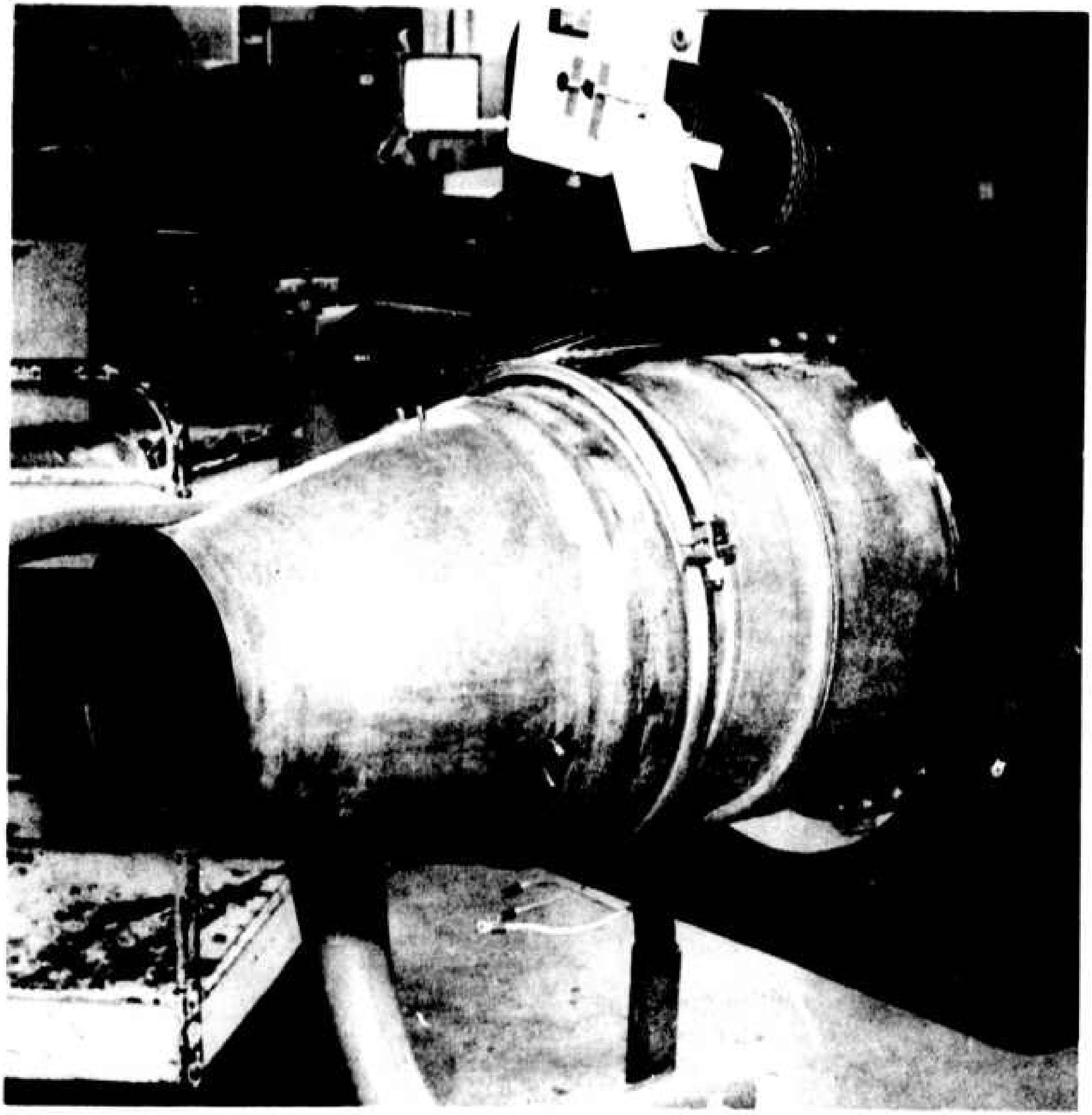


Figure 66. IFRT Engine Model XJ401-GA-400
(Right Rear Oblique View).

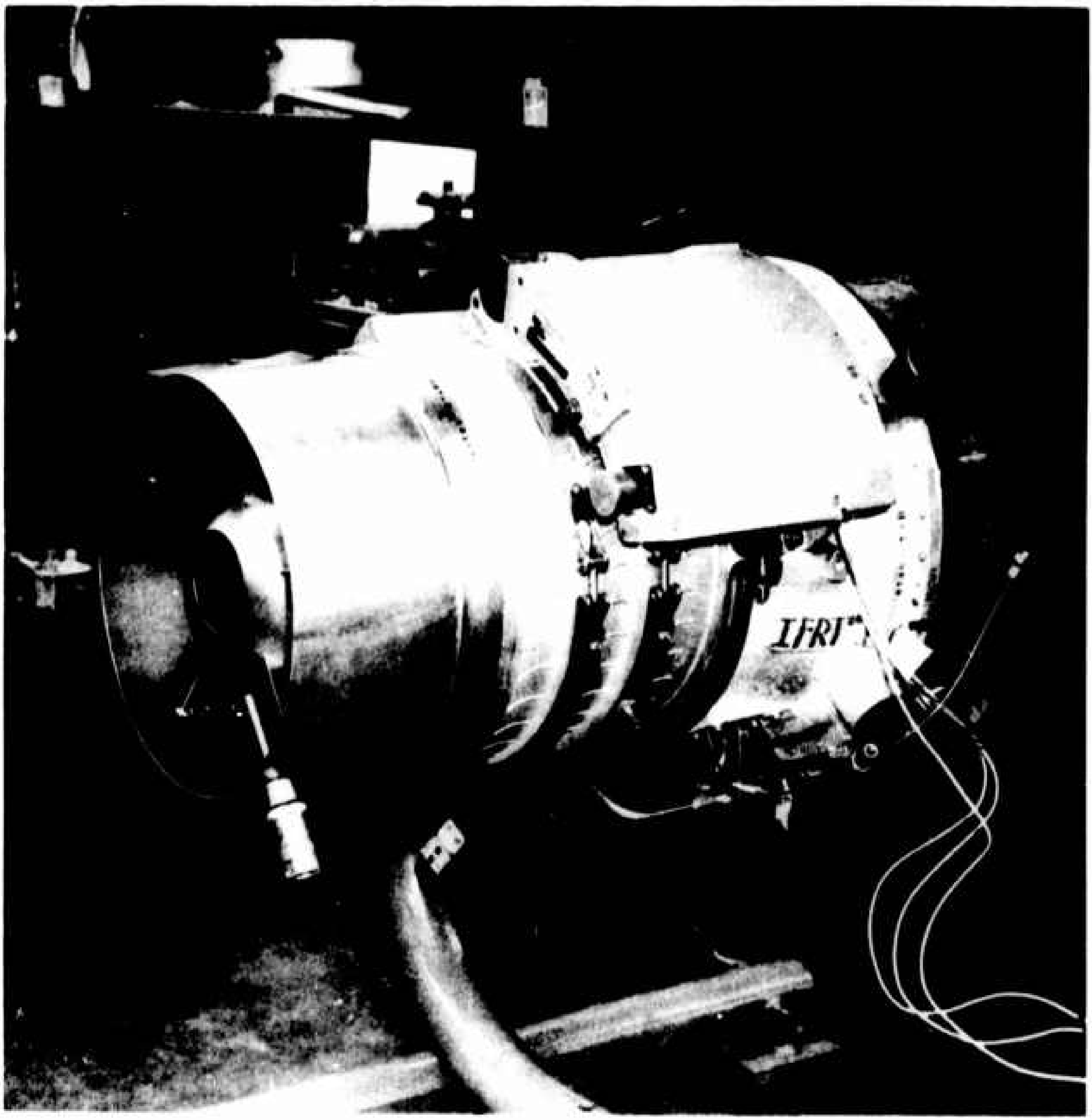


Figure 65. IFRT Engine Model XJ401-GA-400
(Left Front Oblique View).

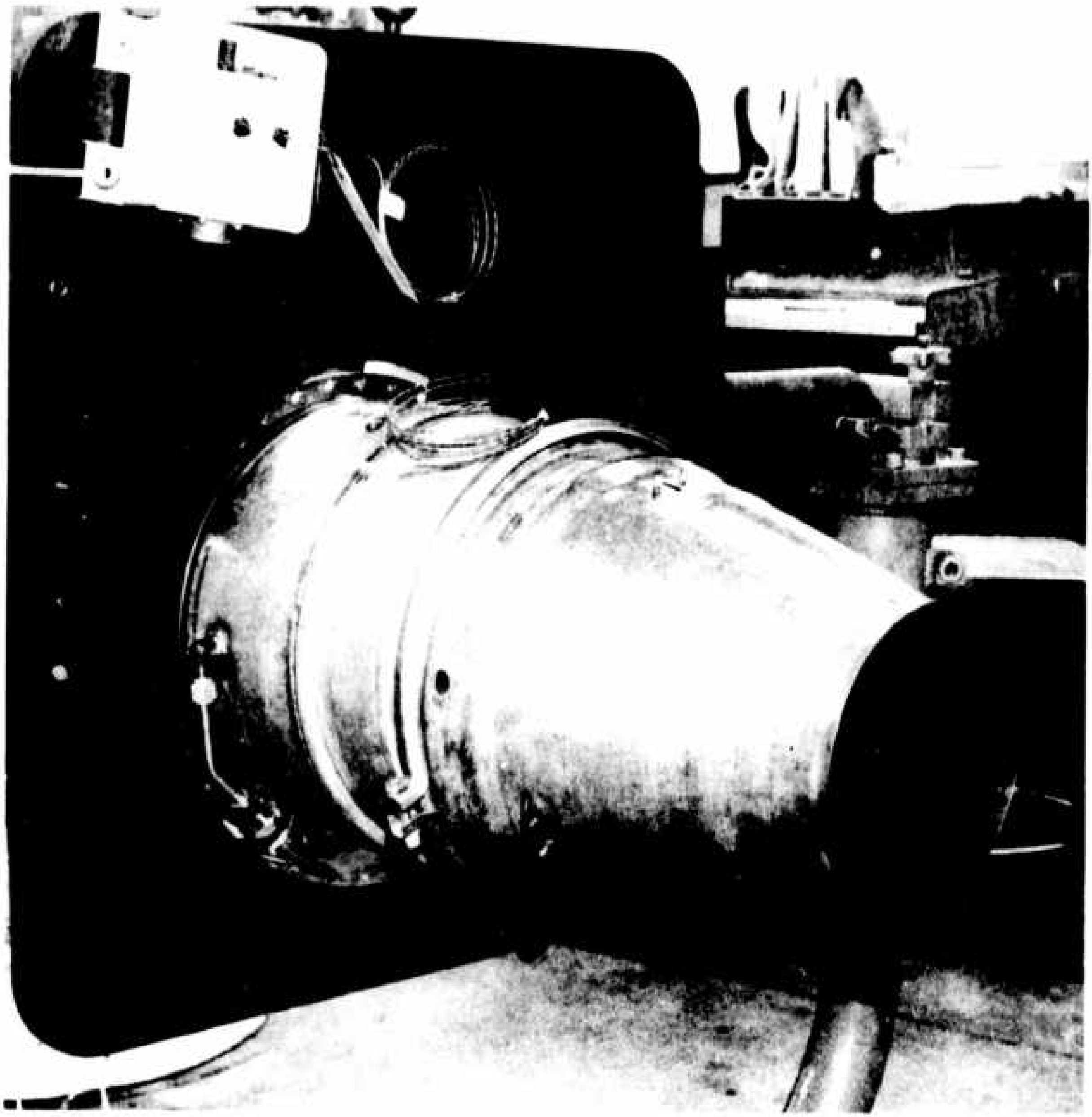


Figure 67. IFRT Engine Model XJ401-GA-400
(Left Rear Oblique View).

Large Altitude and Cold Chamber No. 2. The exterior of the chamber and the interior of the control room are shown in Figure 68. The air inlet ducting and a portion of the interior of the chamber, the control and instrument panels of the control room are shown in photographs contained in Section 6.2.

The handling and maneuvering loads test was conducted on the centrifuge test rig at the AiResearch San Tan Facility. The centrifuge with the engine mounted in the Y axis is shown in Figure 69.

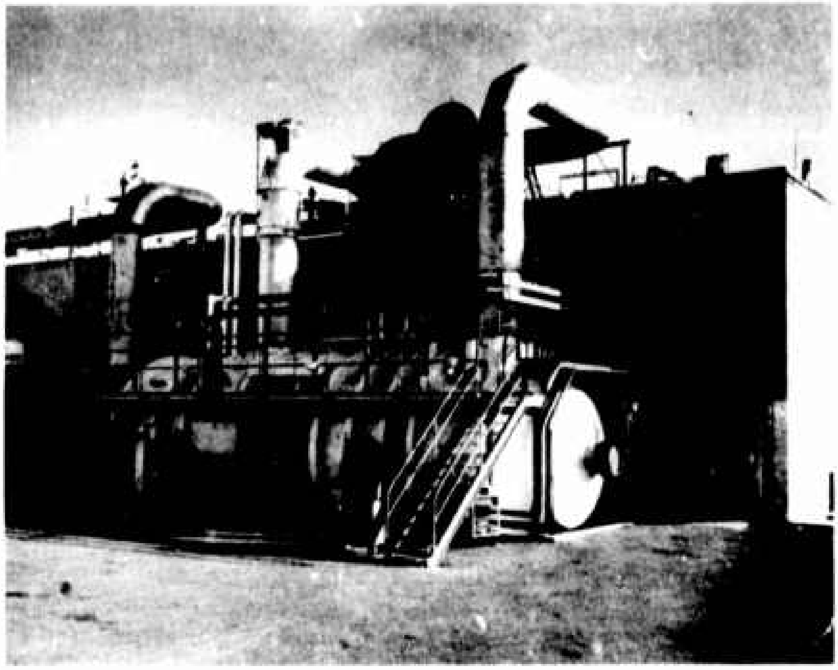
5.5.2 Engine Installation

The engine installed in the Altitude Chamber thrust stand is shown in Figure 70. A close-up view is shown in Figure 71.

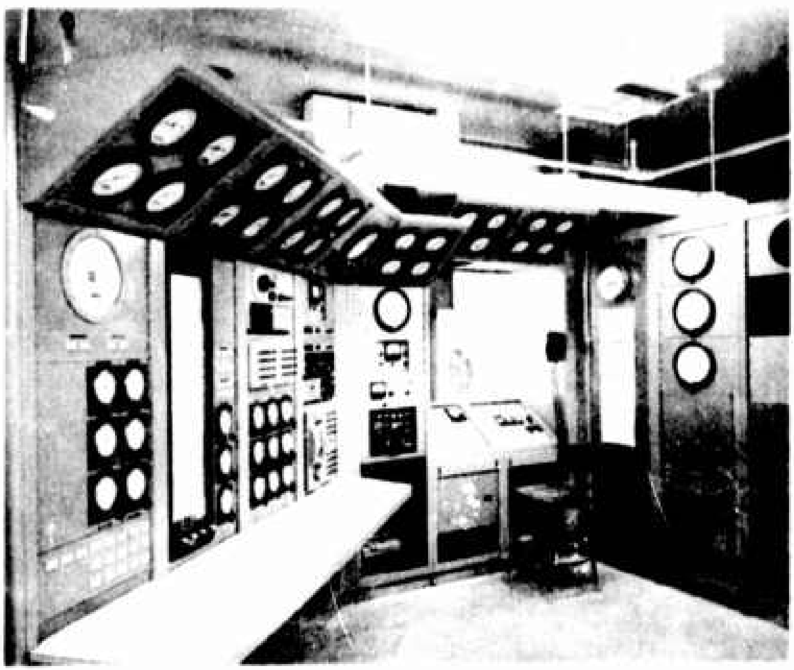
Isolation of the engine from the inlet ducting was accomplished with use of a labyrinth seal at the engine inlet. The isolation was verified prior to the engine tests by application of a measured force to the engine mount ring and comparison of this force with the control room thrust readout. The readout was within 1 pound of the applied force, with the applied force equal to 600 pounds.

Figure 72 presents a schematic that shows the plenum used to duct the inlet air to the engine. The plenum acts as a mixing chamber for the conditioned air supplied to the engine. It also contains a bellmouth, inlet condition sensing probes, and a dump valve. The plenum permits operation of the engine at the required inlet pressures and temperatures.

A vacuum system evacuates the chamber to maintain the required ambient altitude and exhaust pressure conditions.



EXTERIOR VIEW



CONTROL ROOM

Figure 68. Large Altitude and Cold Chamber No. 2.

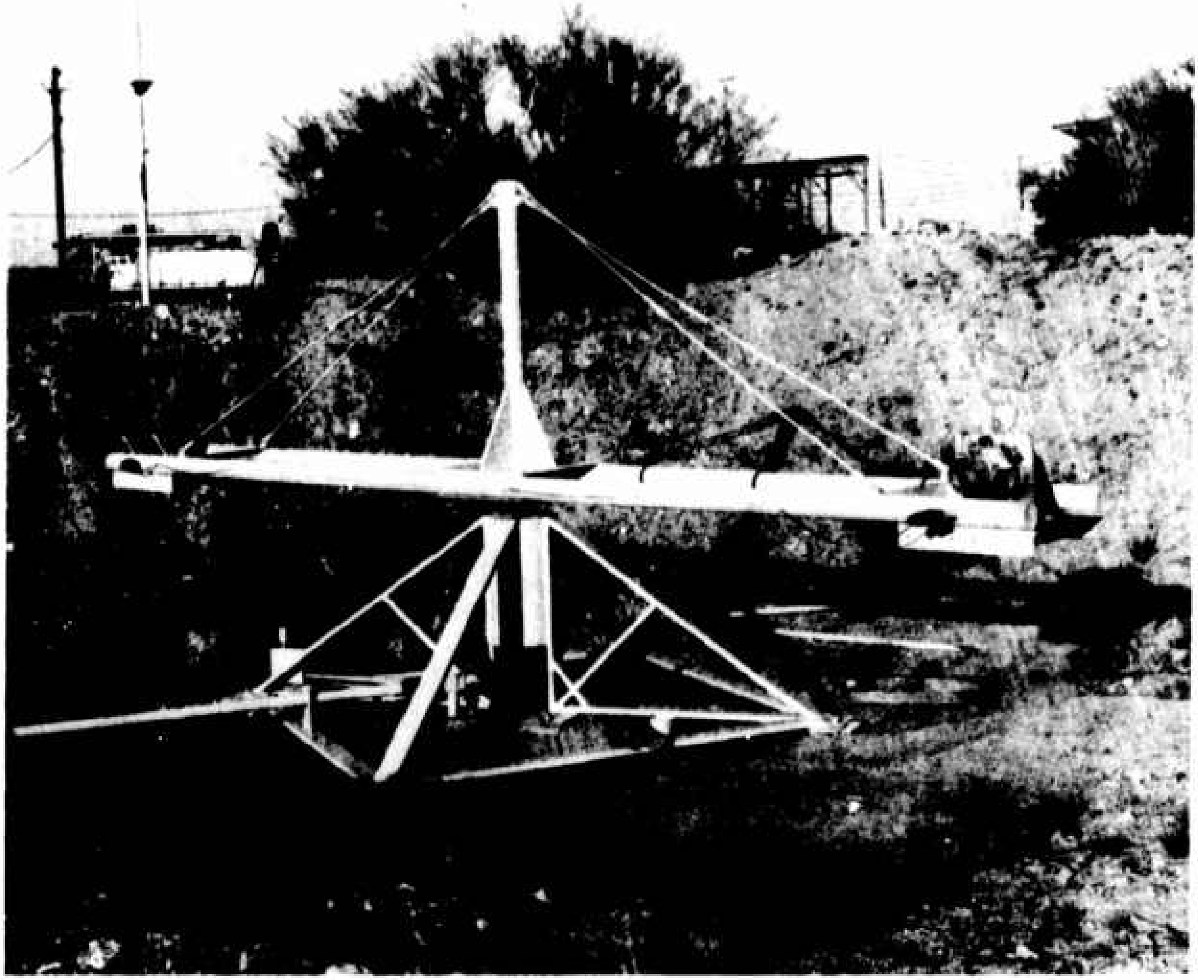


Figure 69. Engine Installed on the Centrifuge in the Y-Axis.

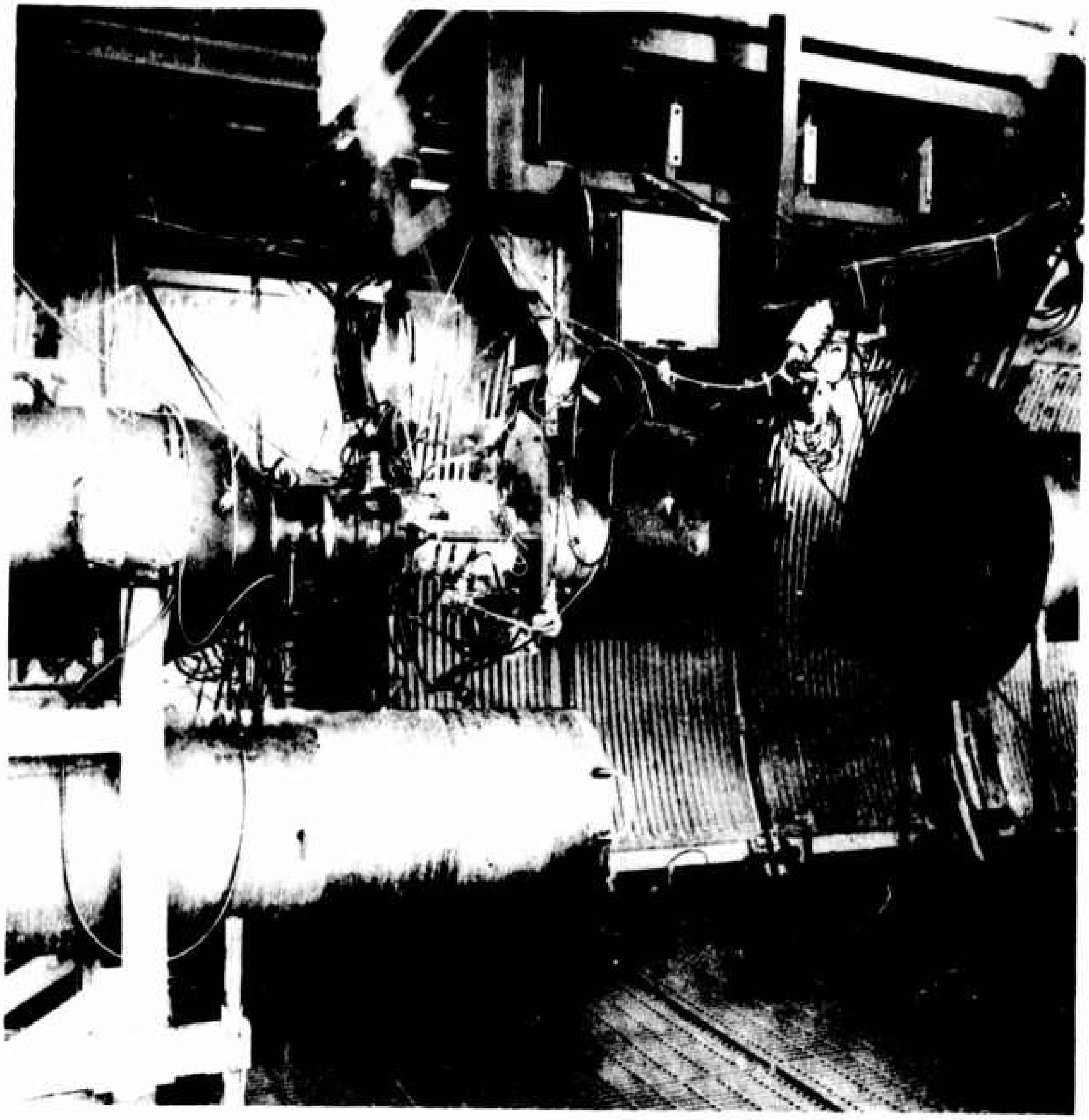


Figure 70. Engine Mounted on the Thrust Stand in the Altitude Chamber.

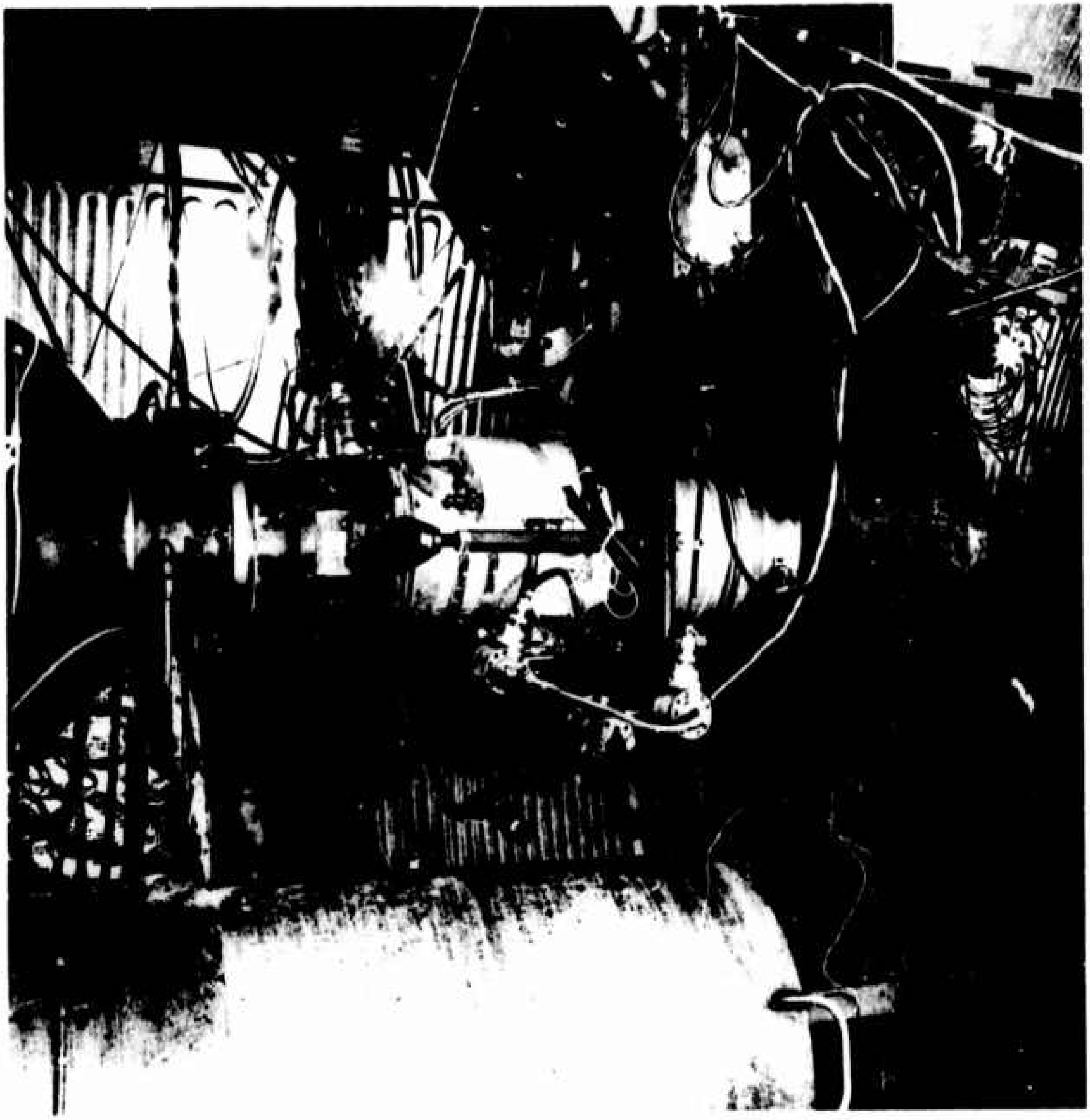


Figure 71. Close-up View of Engine Mounted on the Thrust Stand in the Altitude Chamber.

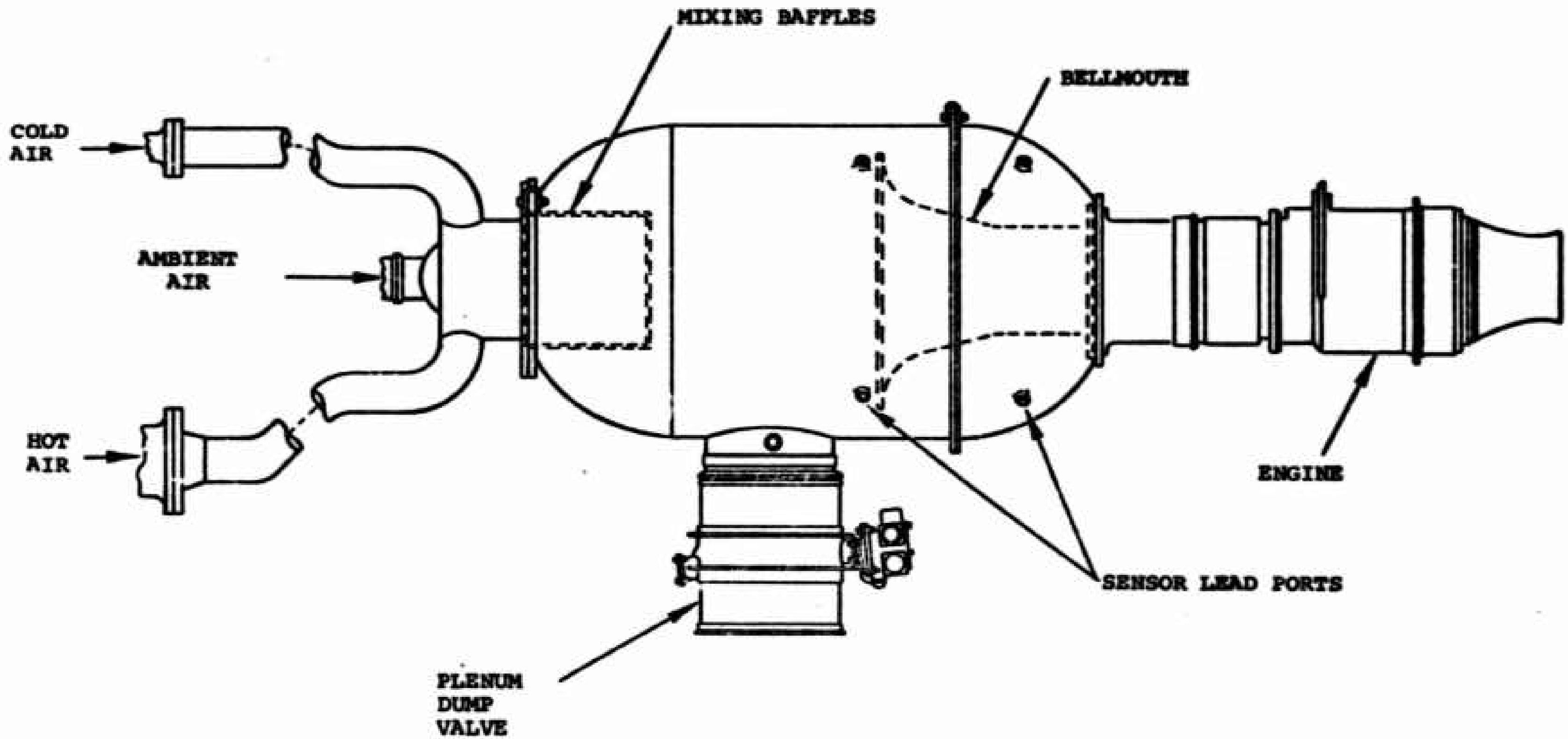


Figure 72. Altitude Chamber Inlet Plenum Schematic.

The electrical system used for starting, stopping, and overspeed protection of the engine is shown in Figure 73. Safety for the pyrotechnic circuits was provided by an electrical connector wired, as shown in Figure 73, so that when installed in the chamber it both grounded the circuits and ensured interruption of the power supply. Further protection against inadvertent firing of the pyrotechnic devices was provided by a key-actuated switch in the control circuits.

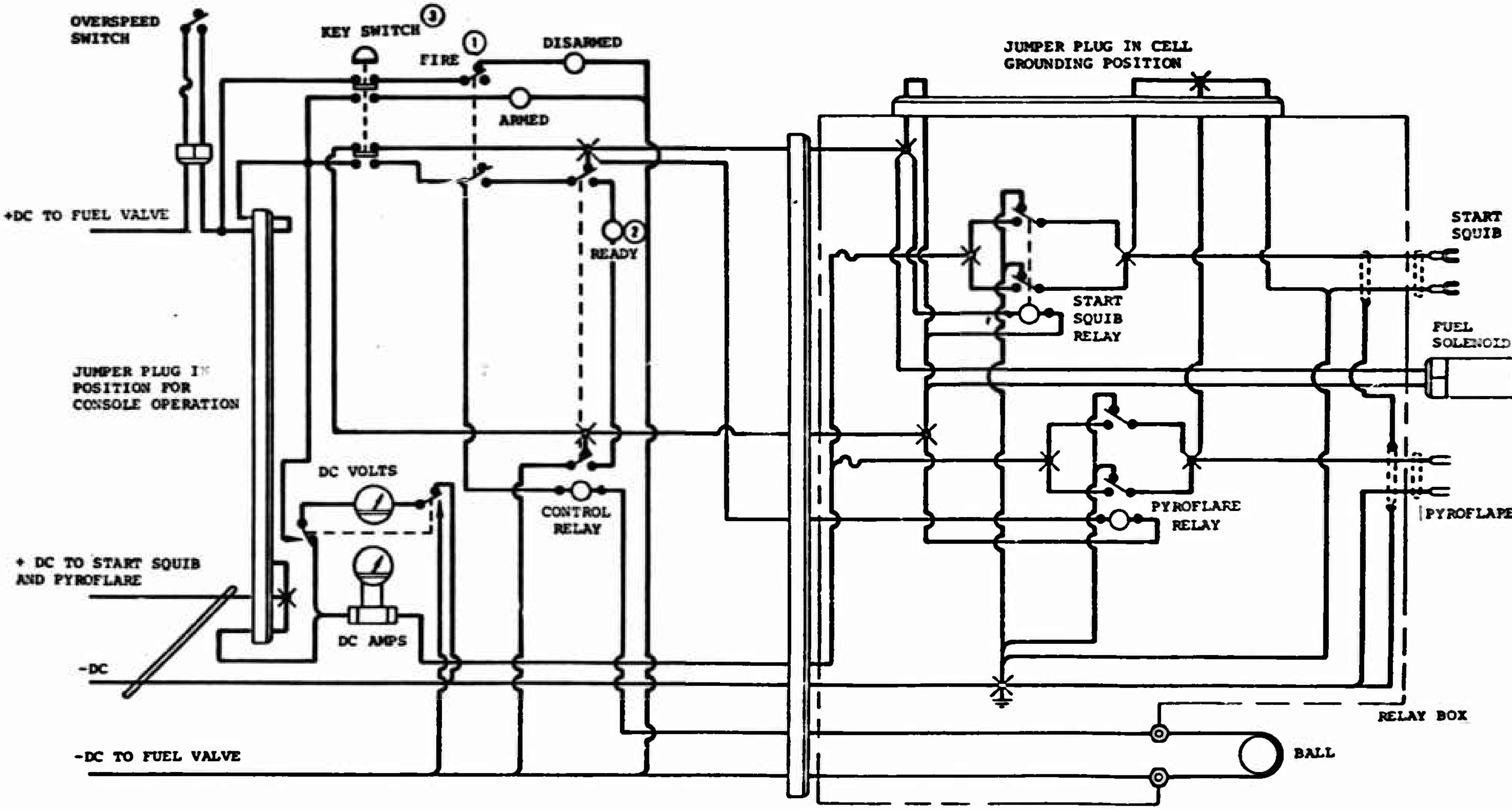
The engine test setup in the altitude chamber is own schematically in Figure 74.

5.5.3 Instrumentation

The tests were conducted with the engine installed in a fully instrumented test setup. The parameters measured and the methods of recording them are listed in Section 6.2.

All instrumentation was of the laboratory precision type, and was certified by standards derived from those of the National Bureau of Standards. Certification of instrumentation used during testing was accomplished by the AiResearch Instrumentation Laboratory under the surveillance of the AiResearch Quality Control Department. A tag or label denoting the date of calibration and date of expiration of the certification was attached to each instrument.

The equipment and instrumentation used for the tests are listed in Section 6.2. This table lists the instrument type; manufacturer; model, type, or size; range; and accuracy limits. Specific information concerning the instrumentation used, including serial numbers, date of calibration certification, and location of the instrument in the test setup, is also shown in Section 6.2.



① FIRING SWITCH WHEN BALL IS NOT USED. ALSO ARMING SWITCH FOR BALL FIRING.

② FOR USE WITH BALL ONLY

③ KEY SWITCH IS OF A DESIGN THAT WILL NOT PERMIT KEY REMOVAL WITHOUT BEING IN "OFF" POSITION.

Figure 73. Electrical Control System.

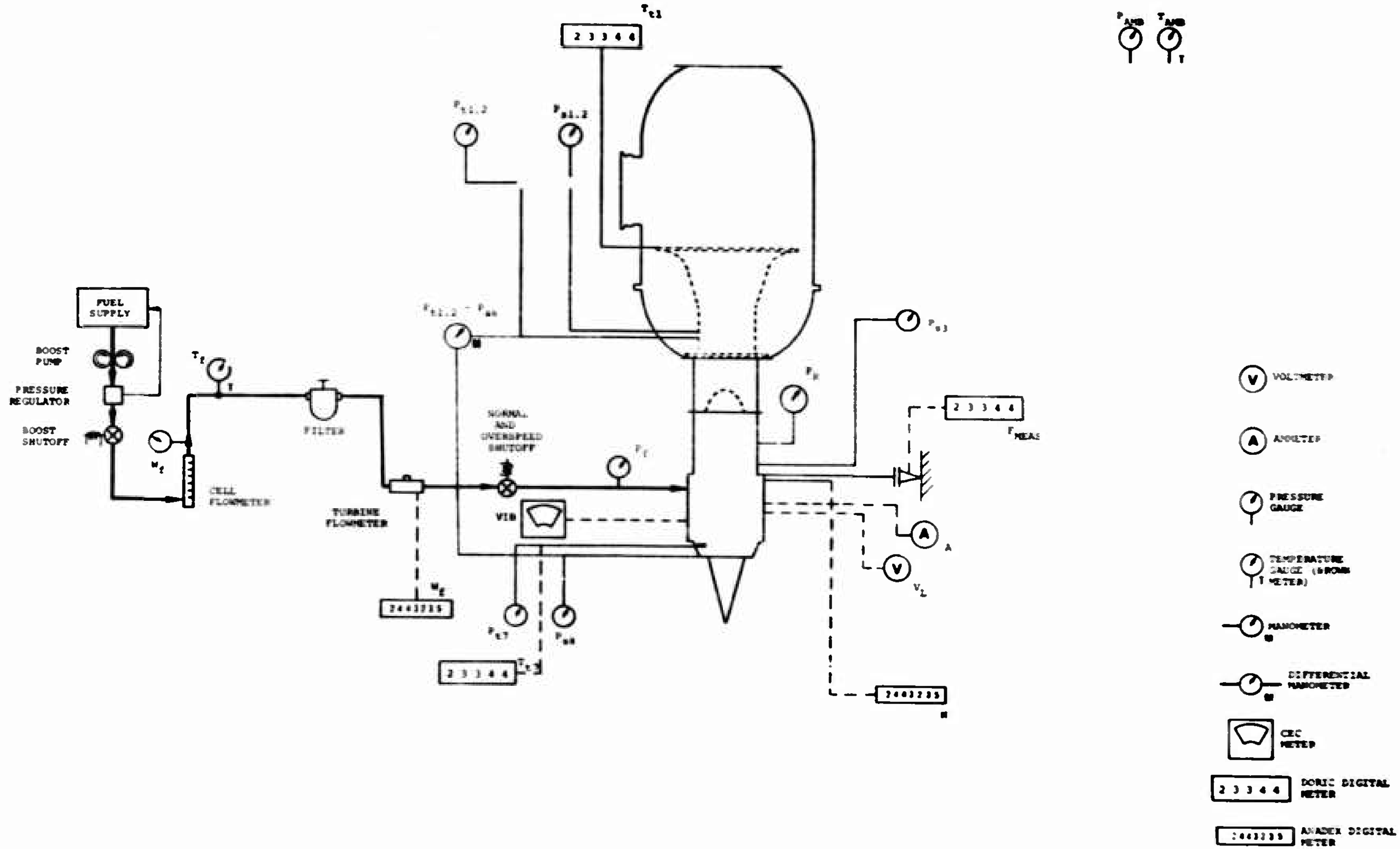


Figure 74. Engine Test Setup in the Altitude Chamber.

5.6 Test Procedure

Testing was conducted in accordance with the Initial Flight Rating Test Procedure, QT-8090A.

Prior to starting the initial flight rating tests, each engine satisfactorily completed a green run, followed by an acceptance test in accordance with ATP-8030, Rev. 6, dated January 18, 1973. The run time during acceptance testing for engine No. 1 was 4.4 minutes, and for engine No. 2, 4 minutes. The other tests, as listed above for each engine, are summarized by engine number as follows:

IFRT Engine No. 1 - The engine was installed in the test chamber with a 10-percent CDI screen in the inlet. Following a low-temperature soak at minus 65°F for 10 hours, the engine was cartridge-started at a simulated altitude of 20,000 feet (cold day), inlet Mach No. 0.38. The start was successful, and after stabilization of 1 minute at these conditions, the engine was transitioned to an inlet Mach number of 0.90 at 20,000 feet and then to sea level at Mach No. 0.90 and run for 1 minute at each condition at maximum thrust. The operating conditions were again changed to transition the engine to the design-point test condition (Condition 4, tropical day, Mach 0.85, sea level), and the engine was run at this condition until shut down. The engine performance and vibration levels throughout this test were satisfactory, and the engine accumulated a total run time of 20.5 minutes, with shutdown due to a change in bearing temperature.

IFRT Engine No. 2 - This engine was subjected to the handling and maneuver loads test on a centrifuge, in which the engine received loads of 17.5 g's in each of three mutually perpendicular planes. A visual inspection of the engine following the test showed no

damage. The engine was then installed in the altitude chamber and subjected to the high-temperature soak test at 160°F ambient for 10 hours. Following completion of the soak period, the engine was cartridge-started at a simulated altitude of 20,000 feet (hot day), inlet Mach number of 0.6 (Condition 5). The start was successful, and after stabilization at the start condition and a run time of 1 minute, the engine was transitioned to the design point (Condition 4, tropical day, Mach 0.85, sea level) and was run at this condition until shut down. The engine accumulated a total run time of 26.2 minutes, with shutdown due to a change in bearing temperature.

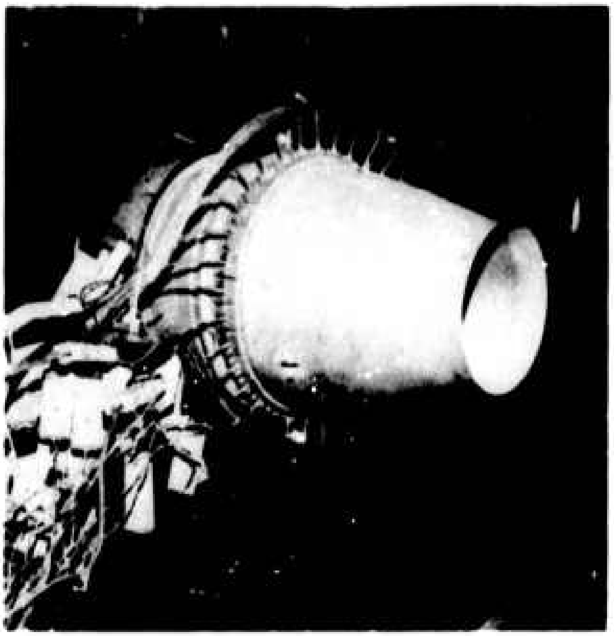
Disassembly inspection of each engine showed all components to be in excellent condition and capable of continued operation, except for the thrust ball bearing.

5.7 Test Results

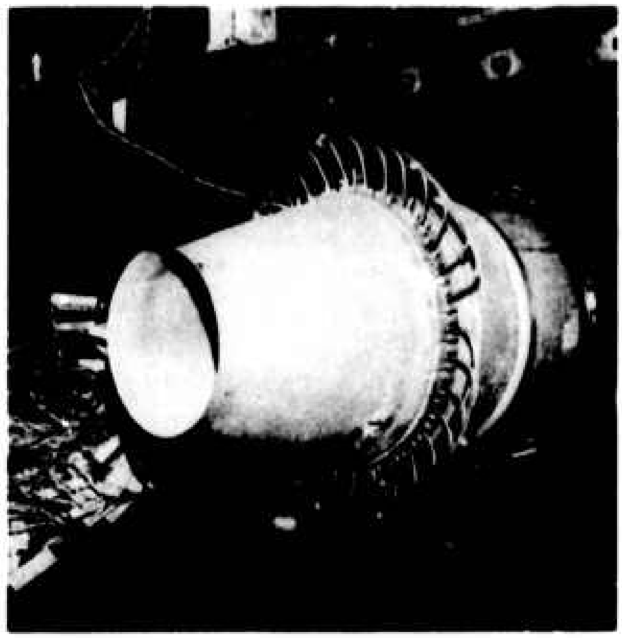
5.7.1 IFRT Engine No. 1

5.7.1.1 Green Run

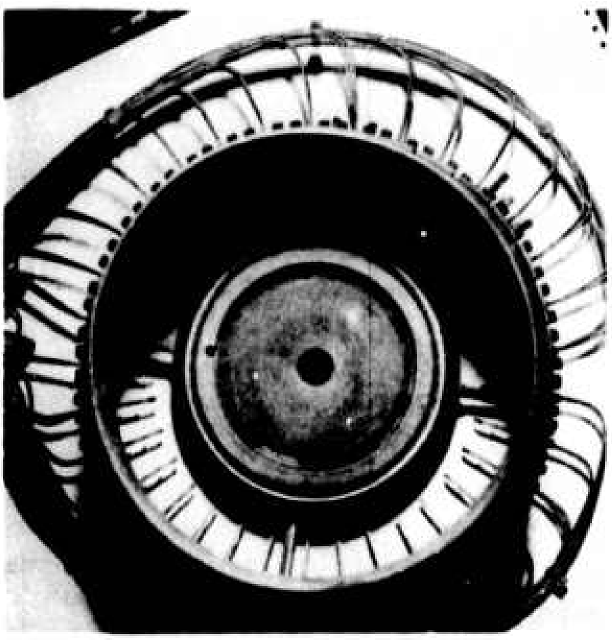
Prior to the acceptance test, the engine was assembled with the improved diffuser-combustor assembly (see Paragraph 4.9), and subjected to a green-run. The test was conducted on the engine test stand with a special exhaust nozzle equipped with 99 thermocouples to measure T_{t5} as shown in Figure 75. The purpose of the green run was to determine the temperature spread factor (TSF). The maximum allowable TSF at a fuel-air ratio of 0.019 is 0.34. The actual TSF for this engine was 0.23 and the data for this test are contained in Section 6.4. The engine was tested at the following conditions:



LEFT SIDE VIEW



RIGHT SIDE VIEW



VIEW LOOKING FORWARD

VIEW LOOKING AFT

Figure 75. Instrumented Green-Run Exhaust Nozzle (T_{t7} Rakes Not Shown).

Altitude	=	Phoenix
Mach number	=	0.85
Total inlet temperature	=	50°F
Fuel flow	=	930 pph

5.7.1.2 Acceptance Test

The acceptance test was conducted in accordance with ATP-8030, Rev. 6, on April 6, 1973. The engine, installed in the Altitude and Cold Chamber No. 2 (see Figures 68, 70, and 71) completed a Phoenix altitude windmill start, and the control was set to provide specification thrust. After setting the control, a 10-percent inlet distortion screen was installed in the engine inlet and a 20,000-feet-altitude cartridge start was made. The run time during the acceptance test was 4.4 minutes.

The net thrust produced exceeded the minimum thrust required. The corrected engine performance data and log sheet for the test are contained in Section 6.4. Two separate automatic recordings (Sanborn traces) were made of the required parameters; they are identified as Traces No. 1 and 2, and are also contained in Section 6.4.

5.7.1.3 Low-Temperature Soak

Following completion of the acceptance test, the engine remained in the altitude and cold chamber, and was subjected to a 10-hour cold soak in accordance with QT-8090A. The chamber ambient temperature was reduced until the engine skin temperature on the plenum indicated minus 65°F, the starting point for the 10-hour soak. A data sheet for the low-temperature soak is contained in Section 6.4.

At the end of the soak period, a check was made of the printout from the digital computer, and data point P_{t7} was found to be inoperative. It was found that due to the extreme cold temperature, the data point selector (laboratory equipment) had malfunctioned. Consequently, P_{t7} was manually recorded during the remainder of IFRT No. 1 tests.

5.7.1.4 Altitude Start

Following completion of the 10-hour minus 65°F soak, the engine was cartridge-started at a simulated altitude of 20,000 feet (cold day) Mach 0.38, with inlet distortion. The start was successful, and the engine was run for 1 minute at the start condition (Condition No. 1). During this condition, the required data scan was made; and the recording traces, identified as trace No. 1 and No. 2 for IFRT No. 1, are contained in Section 6.4.

Prior to the successful altitude start reported above, two unsuccessful starts were attempted. The first attempt was unsuccessful due to the pyro-flare igniter not operating because of miswiring in the electrical connector. The second unsuccessful attempt was caused by an insufficient burn of the starter squib. The squib came from a new purchase lot of squibs, in which many were found to be defective. Details of the correction of these problems are presented in Paragraph 5.8.2.

The minus 65°F ambient temperature was maintained in the chamber during the igniter or squib replacements, to prevent disruption of the cold-soak effect.

5.7.1.5 Inlet Distortion Operation

During the altitude start of the acceptance test and for all IFRT No. 1 tests, a blockage screen was installed in the duct upstream of the engine inlet. This screen, as shown in Figure 76, produced a one-per-revolution 180-degree inlet air-pressure distortion pattern. The circumferential distortion index (CDI) measured during design-point operation was 12.4 percent. Detailed information on this screen is presented in Paragraph 5.8.1.

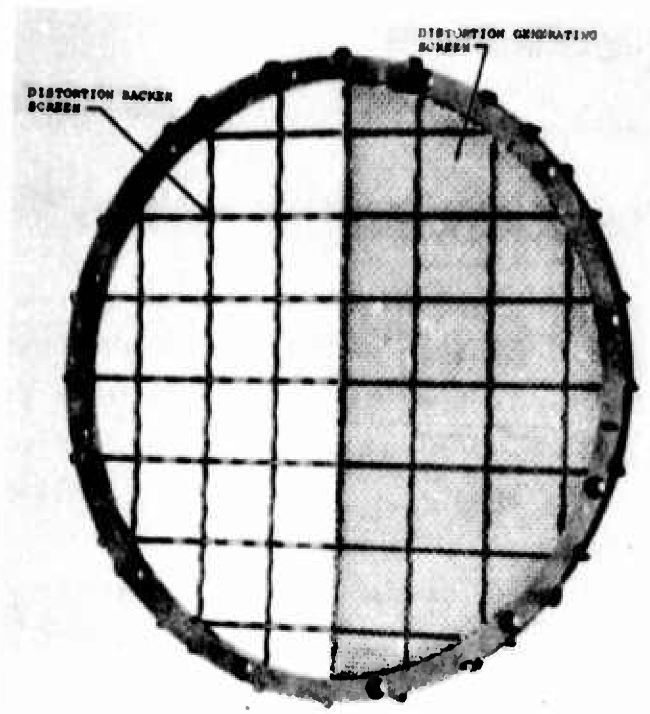


Figure 76. Inlet Distortion Screen.

After running at 20,000 feet, Mach 0.38, and minus 34°F total inlet temperature for 1 minute, the engine was transitioned into Condition No. 2 by first increasing the inlet total temperature to plus 21°F, and then increasing the ram ΔP to achieve a simulated Mach number of 0.90 while maintaining 20,000 feet. The engine was run at this condition for 1 minute. The engine was then transitioned into Condition No. 3 in steps as follows:

(a) Inlet total temperature increased to 110°F
(b) Ram ΔP increased to 17 inches Hg
(c) Altitude reduced to Phoenix
(d) Ram ΔP final increase to 23.5 inches Hg (Mach 0.90)
(e) Inlet total temperature final increase to 179°F

The engine was run at Phoenix altitude, Mach 0.90, and 179°F total inlet temperature (Condition 3) for at least 1 minute.

The IFRT tests demonstrated the ability of the engine to start and operate satisfactorily with inlet distortion in excess of the model specification requirement of 10-percent CDI.

5.7.1.6 Design-Point Operation

The engine was again transitioned in two steps to the design point (Condition 4, tropical day, Mach 0.85 at sea level). The inlet total temperature was reduced to 169°F, and then the ram ΔP was reduced to 20.7 inches Hg. The engine was run at this condition until it was shut down due to a change in the engine thrust bearing temperature. The engine accumulated a total run time of 20.5 minutes, with the performance and vibration levels being satisfactory throughout the test.

The engine thrust bearing temperature slope is presented in detail in Paragraph 5.8.3 herein. The vibration survey conducted during the test is presented in detail in Paragraph 5.7.3. The corrected engine design-point performance data and log sheet for the test are contained in Section 6.4. The automatic recordings (Sanborn traces) were reduced for inclusion in this report and are contained in Section 6.4.

5.7.1.7 Disassembly and Inspection

IFRT Engine No. 1 was disassembled on April 9, 1973. The disassembly was witnessed by AiResearch Quality Control and NASC representatives. Each part was visually inspected and the critical parts received a magnetic-particle or fluorescent-penetrant inspection. In addition, the critical parts were dimensionally checked and the dimensions were recorded in the "AFTER" column on the Quality Control Reinspection Record cards. These cards and the teardown deficiency write-up data sheet are contained in Section 6.3.

The ball thrust bearing had experienced distress and all of the sixteen balls showed evidence of metal spalling and melting due to the high temperatures generated. Melted ball material was deposited on the bearing races and on the adjacent end of the alternator. This condition is shown in Figure 77-A,-B, and -C, and Figure 78-A.

A portion of the graphite-filled epoxy abradable coating on the compressor rotor behind the third-stage blades was missing, as shown in Figure 78-B. This condition has commonly been seen on development engines and is considered acceptable after this endurance time.

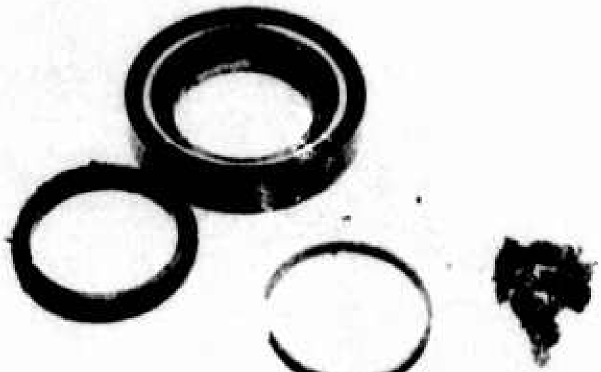
With the exception of a minor rub of the first-stage compressor blade tips as shown in Figure 79-B, the balance of the hardware was in excellent condition, as shown in Figures 77-D; 78-C,-D; 79-A,-C, -D; and 80 through 84. The effective area of the combustor/nozzle assembly was determined by a flow test to be 12.14 square inches. This area is an increase of 1 percent over the 12.01 square inches measured before assembly and test of the engine. This variation is within acceptable limits.

Control system components were examined and tested on the bench following engine teardown, and the test points were within the required limits. Figure 85 shows the pre- and post-test calibration of the Fuel Metering Assembly Part 3740425-1, and Figure 86 shows the pre- and post-test calibration of the Pressure Control Valve Part 3740427. The wiring harness assembly also checked satisfactorily following the test. Data sheets of the pre- and post-test checks of these components are contained in Section 6.4.

5.7.2 IFRT Engine No. 2

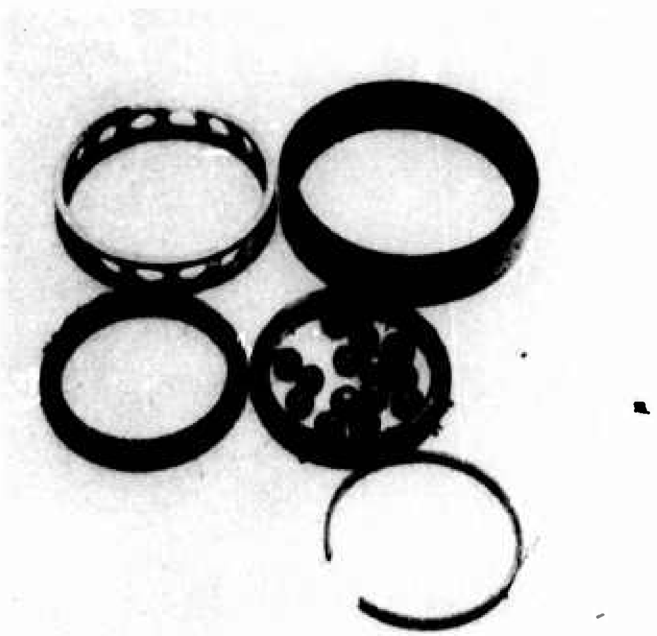
5.7.2.1 Green Run

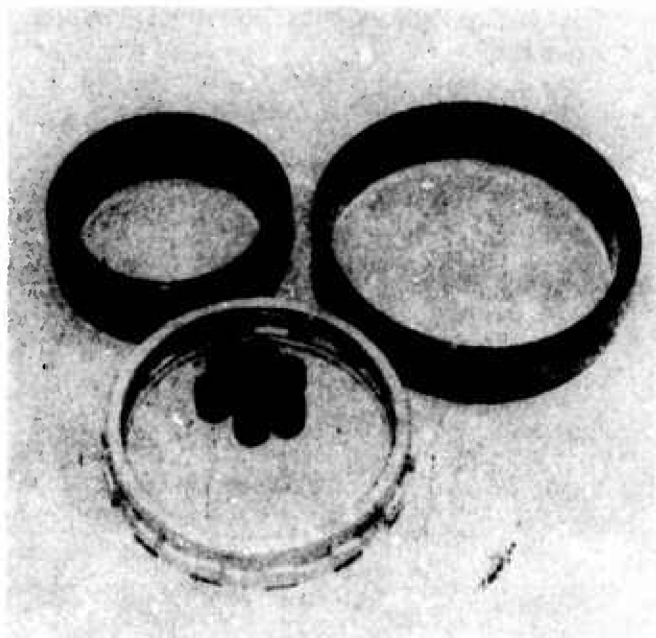
Prior to the acceptance test, the engine was assembled with the improved diffuser-combustor assembly (see Paragraph 4.9) and subjected



A. BALL BEARING PART 3740290-1
SERIAL NO. 3-106

B. BALL BEARING PART 3740290-1
SERIAL NO. 3-106

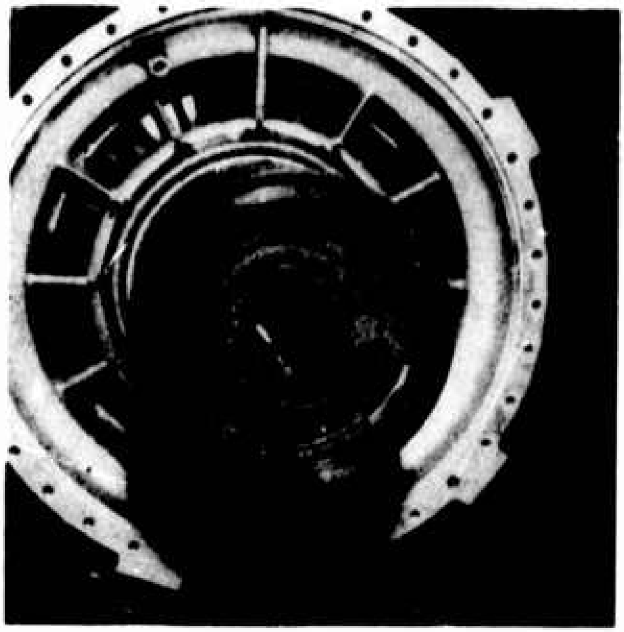




C. BALL BEARING PART 3740290-1
SERIAL NO. 3-106

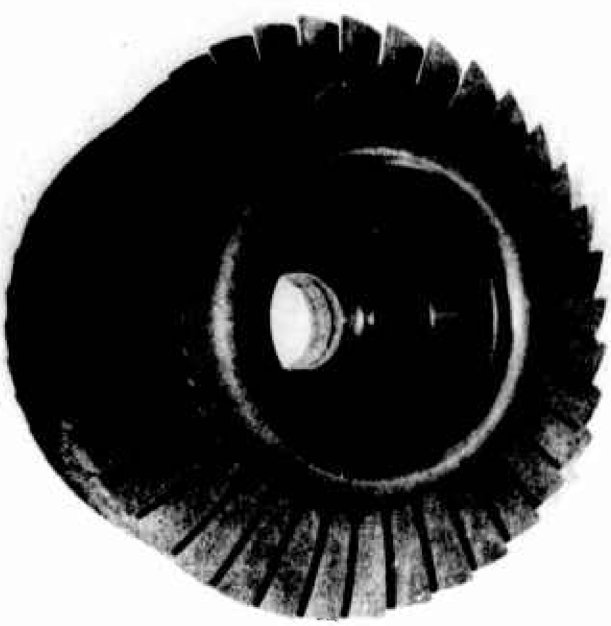
D. ROLLER BEARING PART 358723-2
SERIAL NO. 2708

Figure 77. IFRT Engine No. 1, Condition of Parts after 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.

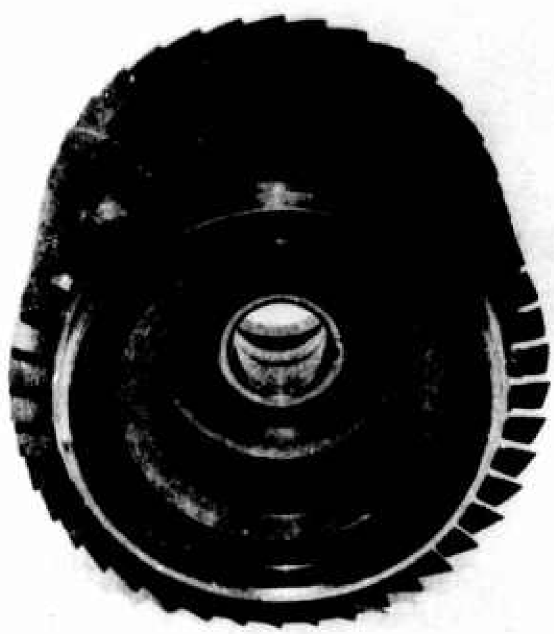


A. MIDFRAME AND ALTERNATOR

B. COMPRESSOR ROTOR PART 3740393-1
SERIAL NO. AC-17

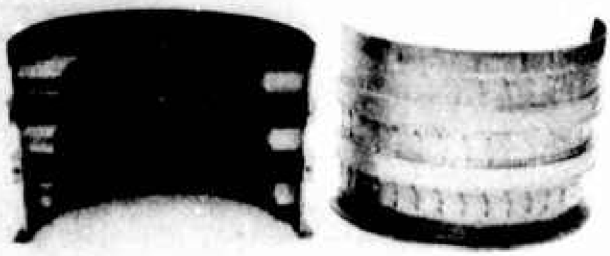


C. COMPRESSOR ROTOR PART 3740393-1
SERIAL NO. AC-17

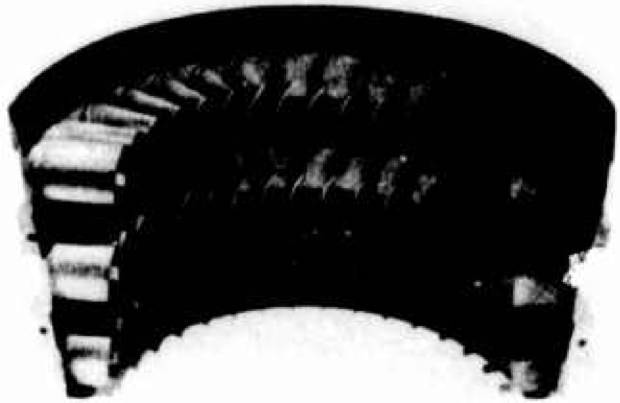


D. COMPRESSOR ROTOR PART 3740393-1
SERIAL NO. AC-17

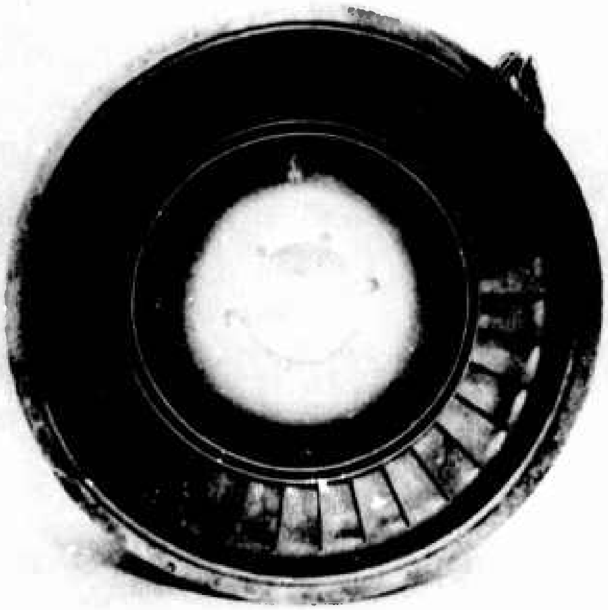
Figure 78. IFRT Engine No. 1, Condition of Parts After 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.



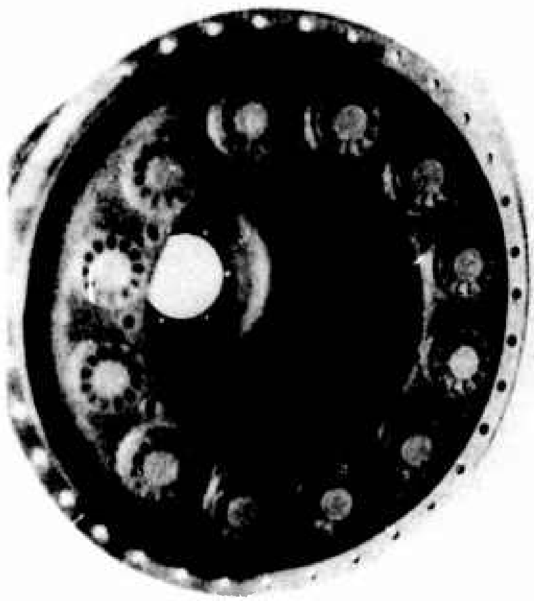
A. COMPRESSOR STATOR PART 3740270-2
SERIAL NO. 72X150



B. COMPRESSOR STATOR PART 3740270-2
SERIAL NO. 72X150

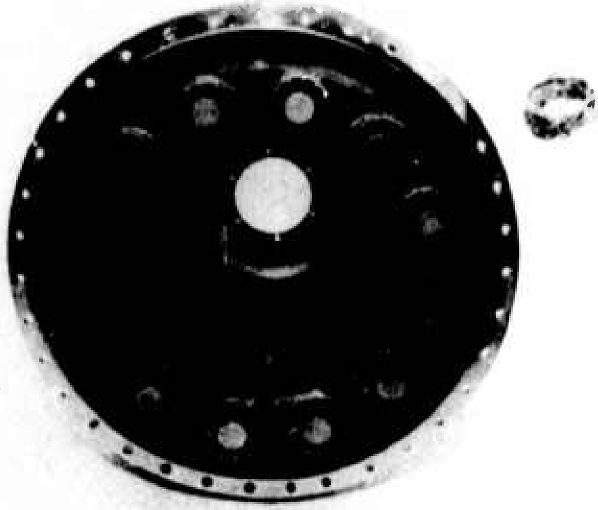


C. COMBUSTOR AND NOZZLE PART
3740292-3, SERIAL NO 1479



D. COMBUSTOR AND NOZZLE PART
3740292-3, SERIAL NO. 1479

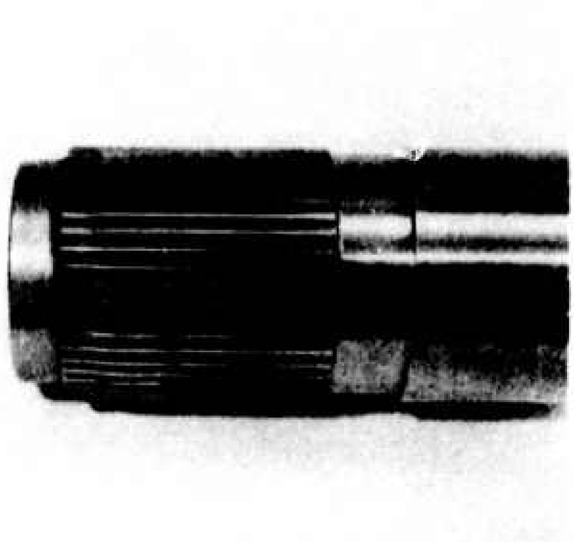
Figure 79. IFRT Engine No. 1, Condition of Parts After 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.



A. COMBUSTOR AND NOZZLE PART 3740292-3, SERIAL NO. 1479

B. TURBINE ROTOR PART 3740283-3 SERIAL NO. 958

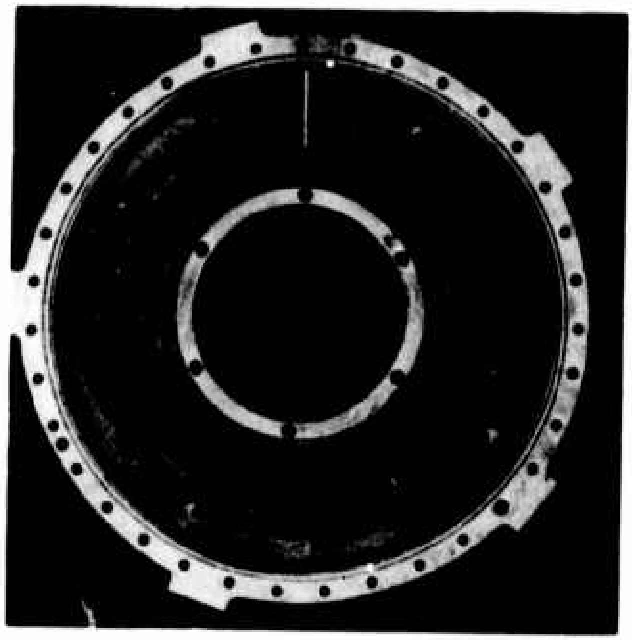
C. TURBINE ROTOR AND SHAFT PART 3740283, SERIAL NO. 958



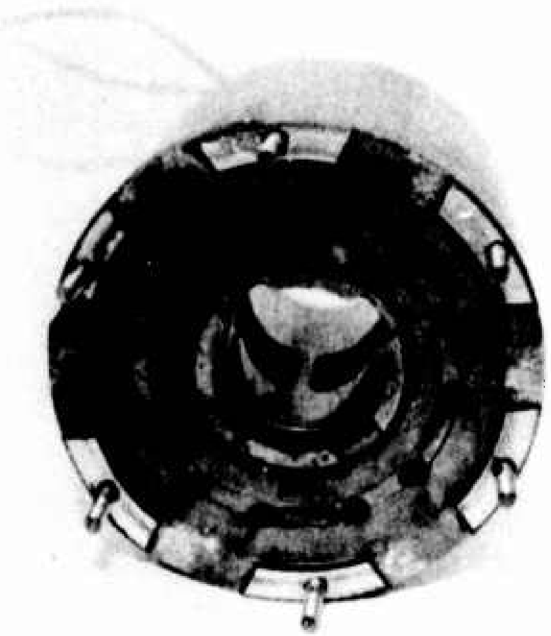
D. SPUR GEAR PART 3740394-1 SERIAL NO. 3

Figure 80. IFRT Engine No. 1, Condition of Parts after 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.

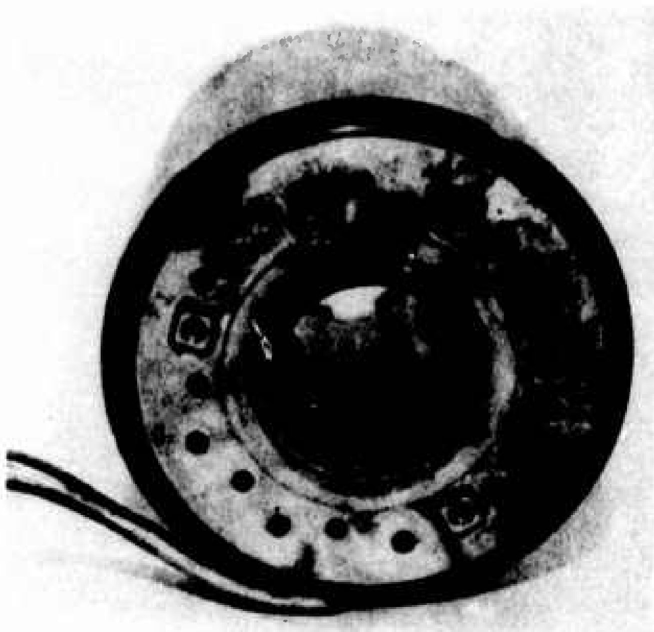
A. MIDFRAME PART 3740387-3
SERIAL NO. 72X126



B. MIDFRAME PART 3740387-3
SERIAL NO. 72X126



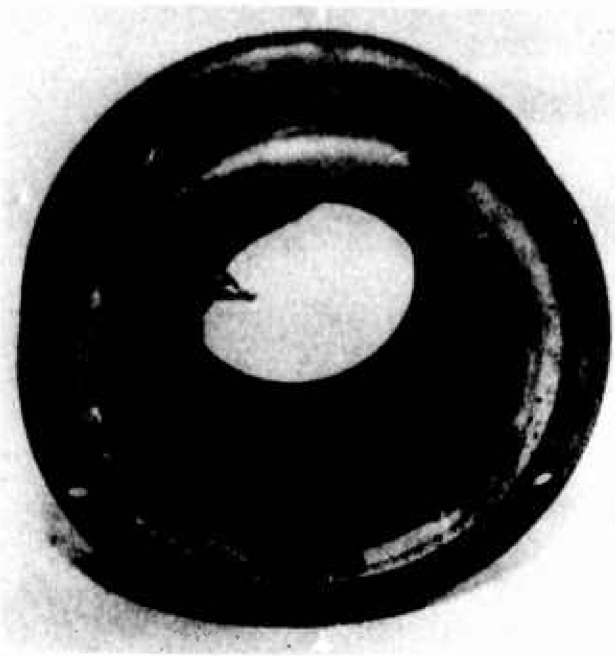
C. ALTERNATOR PART 2045042-1-1
SERIAL NO. 102-147

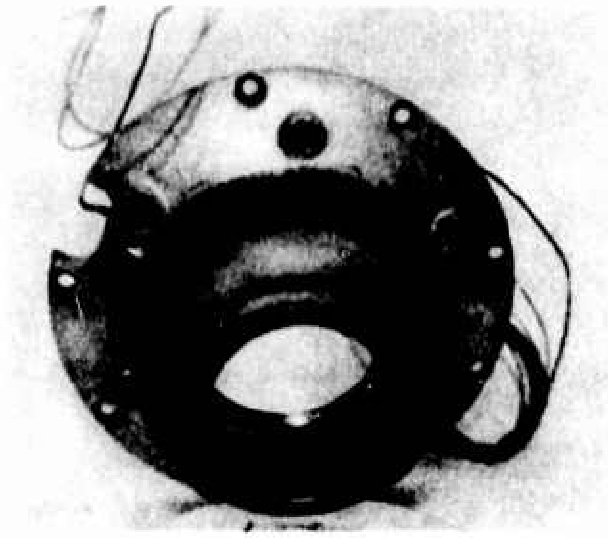


D. ALTERNATOR PART 2045042-1-1
SERIAL NO. 102-147

Figure 81. IFRT Engine No. 1, Condition of Parts After 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.

MP-37695





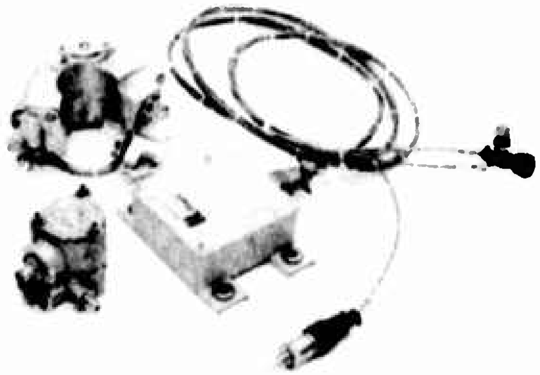
A. REAR BEARING SUPPORT PART 3740409-1, SERIAL NO. 72X126

B. FRONT BEARING SUPPORT PART 3740408-1, SERIAL NO. 72X126

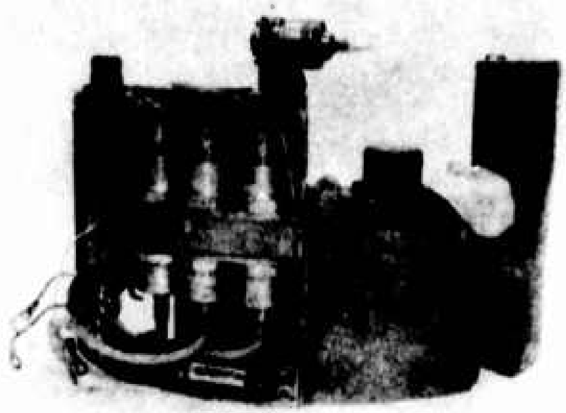
C. STARTER PART 3505055-4

D. EXHAUST NOZZLE PART 3500205-1

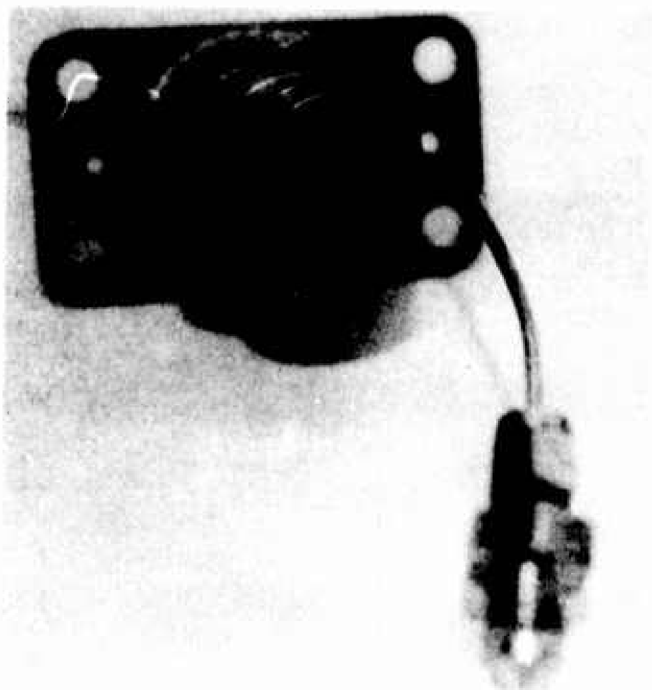
Figure 82. IFRT Engine No. 1, Condition of Parts after 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.



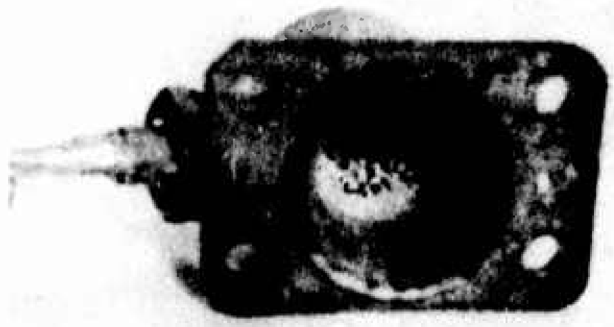
A. FUEL CONTROL SYSTEM



B. POWER CONDITIONER PART 3740463-1
SERIAL NO. 22-119



C. RELIEF VALVE PART 771-612-9301
SERIAL NO. 6



D. PYROTECHNIC IGNITER PART
3740403-1

Figure 83. IFRT Engine No. 1 Condition of Parts after 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.

A. OIL SLINGER PART 3740381-1
SERIAL NO. 3

B. RESILIENT MOUNT PART
3740254-1, SERIAL NO. 3

Figure 84. IFRT Engine No. 1, Condition of Parts after 20 Minutes Endurance Run Time. Test Dates: April 6 and 7, 1973.

MP-37698

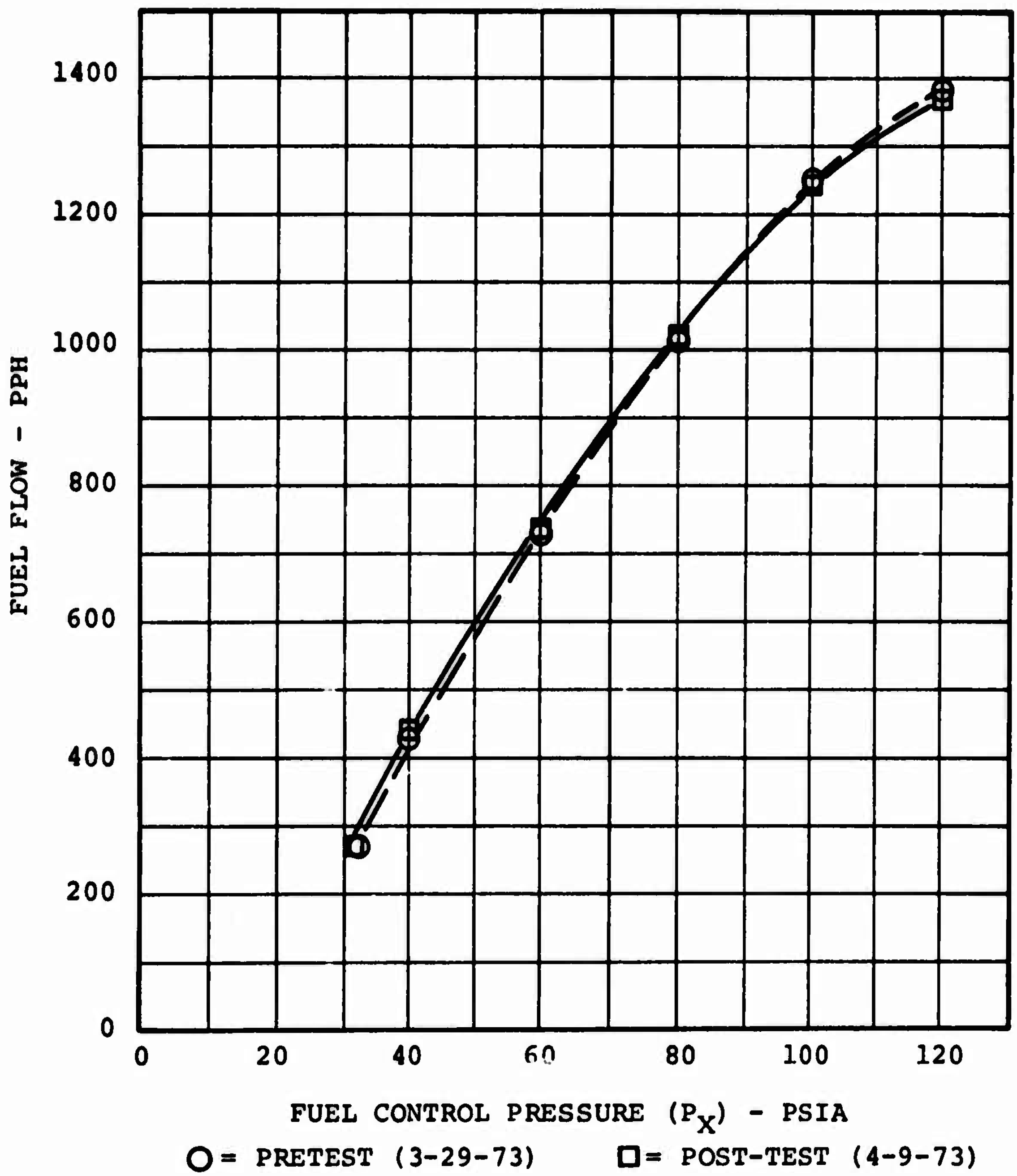


Figure 85. Calibration Results of the Fuel Control Assembly Part 3740425-1, Serial No. 2274-3 (IFRT Engine No. 1).

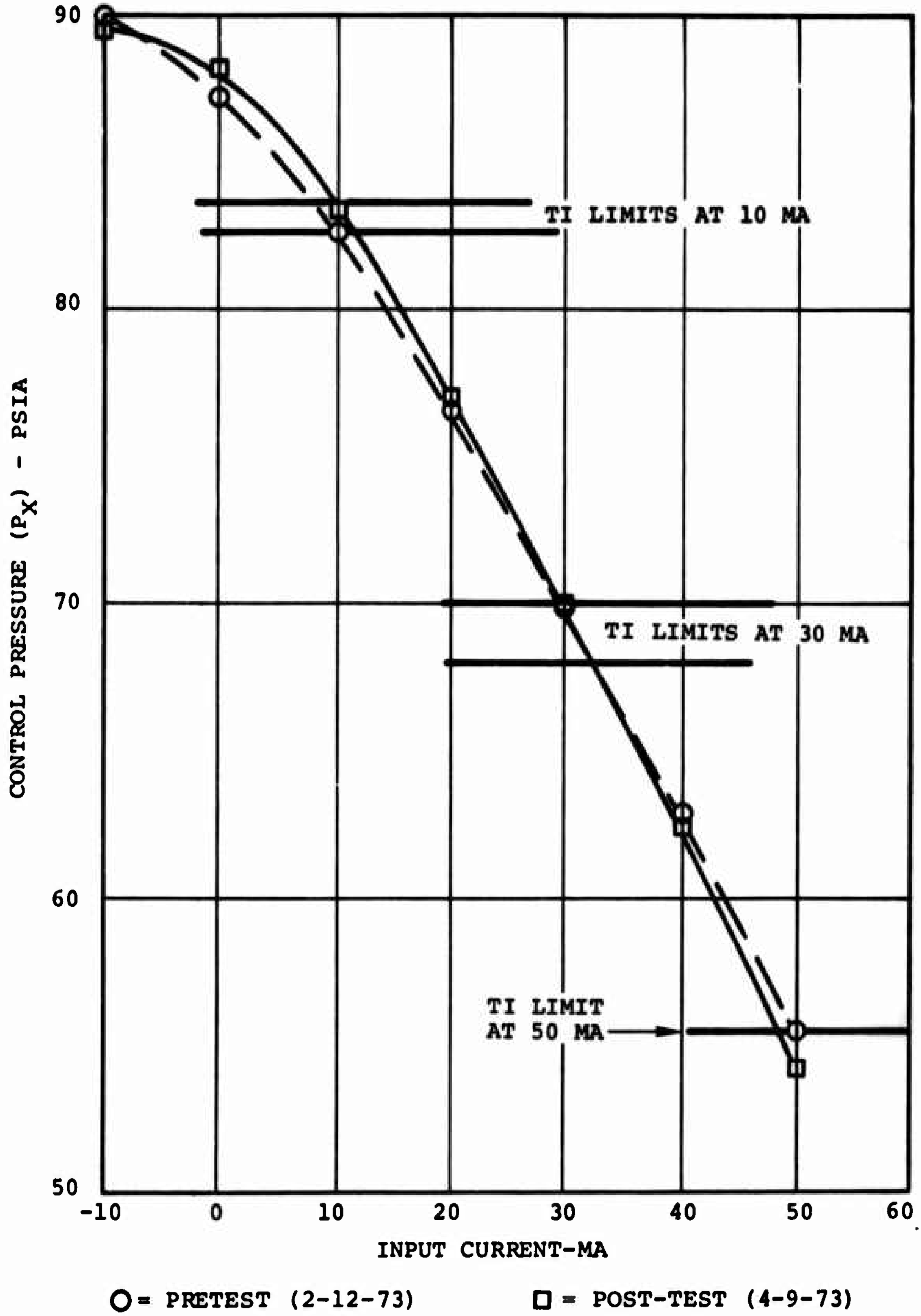


Figure 86. Calibration Results of the Pressure Control Valve Part 3740427-1, Serial No. 009 (IFRT Engine No.1).

to a green run. The test was conducted on the engine test stand with a special exhaust nozzle equipped with 99 thermocouples to measure T_{t5} (see Figure 75). The purpose of the green run was to determine the temperature spread factor (TSF). The limits and conditions for this test are the same as for IFRT No. 1 green run (refer to Paragraph 5.7.1.1). The actual TSF for the engine was 0.23, and the data for this test are contained in Section 6.4.

5.7.2.2 <u>Acceptance Test</u>

The acceptance test was conducted in accordance with ATP-8030, Rev. 6, on April 1, 1973. The engine, installed in Altitude and Cold Chamber No. 2 (see Figures 68, 70, and 71), completed a Phoenix altitude windmill start, and the control was set to provide specification thrust. After setting the control, a 20,000-feet Mach 0.60 altitude cartridge start was made. The run time during acceptance test was 4 minutes.

The net thrust produced exceeded the minimum thrust required. The corrected engine performance data and log sheet for the test are contained in Section 6.4. Two separate automatic recordings (Sanborn traces) were made of the required parameters, and are also contained in Section 6.4.

Prior to the above-described acceptance test, an earlier acceptance test was run on the engine. During inspection of the engine after completing the run (4 minutes in duration) the turbine blades were found to have foreign object damage. Investigation of the engine and test stand ducting revealed no loose items or foreign objects in the system. The conclusion was that there was possible contamination in the processed air supplied to the engine inlet. The damaged components were replaced prior to the successful acceptance test.

5.7.2.3 Handling and Maneuver Loads Test

Following completion of the acceptance test, the engine was transferred to the AiResearch San Tan Facility for the handling and maneuver loads test. The engine was mounted on the centrifuge fixture at a 162-inch radius of rotation, with the front of the engine pointed inboard, representing the X-axis. With the engine in a non-operating condition, the centrifuge was rotated at 61 to 65 rpm for 15 seconds. This rotational speed, with the engine at the 162-inch radius, produced a 17.5-g load. A photograph of the engine mounted on the centrifuge in the X-axis is shown in Figure 87.

The above procedure was repeated with the engine positioned in the Y-axis and the Z-axis. For the Y-axis the engine was positioned with the top inboard and the inlet 90 degrees to the centrifuge arm. For the Z-axis the engine was positioned with the left side outboard and the inlet 90 degrees to the centrifuge arm. Photographs of the engine on the centrifuge in the Y-axis and the Z-axis are presented in Figures 88 and 89.

Following completion of the test, the engine was removed from the centrifuge for a visual examination. This examination revealed no evidence of damage as a result of the test. The engine was then transferred to the Large Altitude and Cold Chamber No. 2 for the high-temperature test.

5.7.2.4 High-Temperature Soak

With the engine installed in the test chamber, it was subjected to a 10-hour high-temperature soak in accordance with QT-8090A. The chamber ambient temperature was increased until the engine skin temperature as measured on the plenum indicated 160°F. The 10-hour soak was started from this point. A data sheet for the high-temperature soak is contained in Section 6.4.

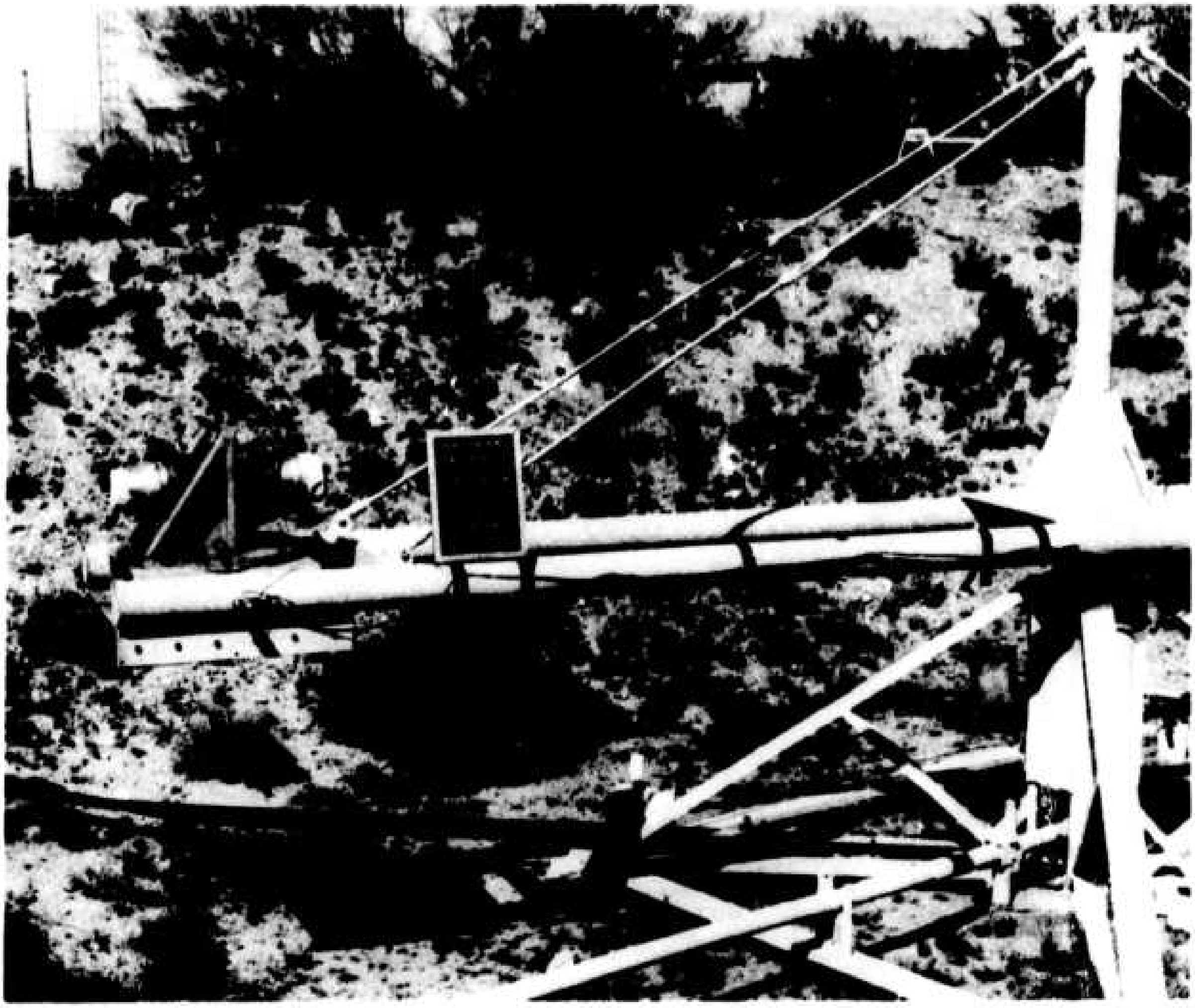


Figure 87. Engine Mounted on the Centrifuge in the X-Axis.

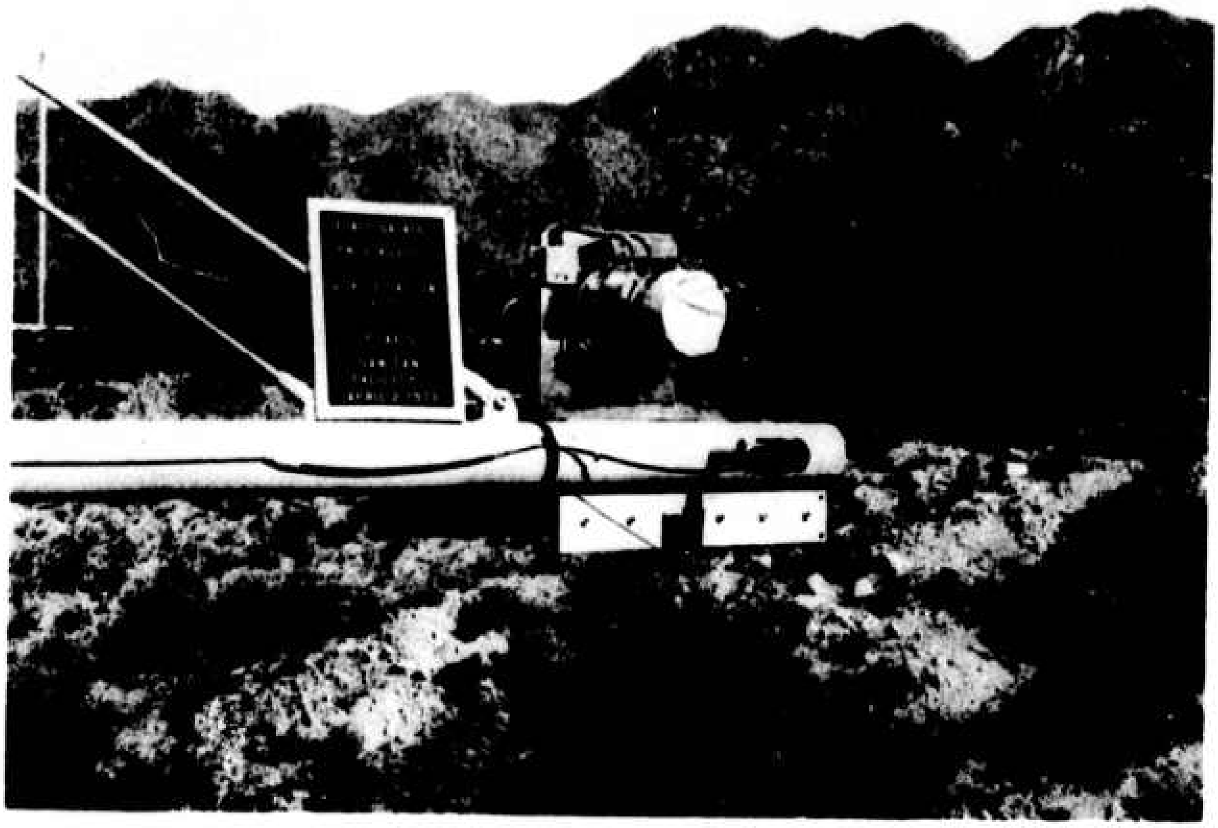


Figure 88. Engine Mounted on the Centrifuge in the Y-Axis.

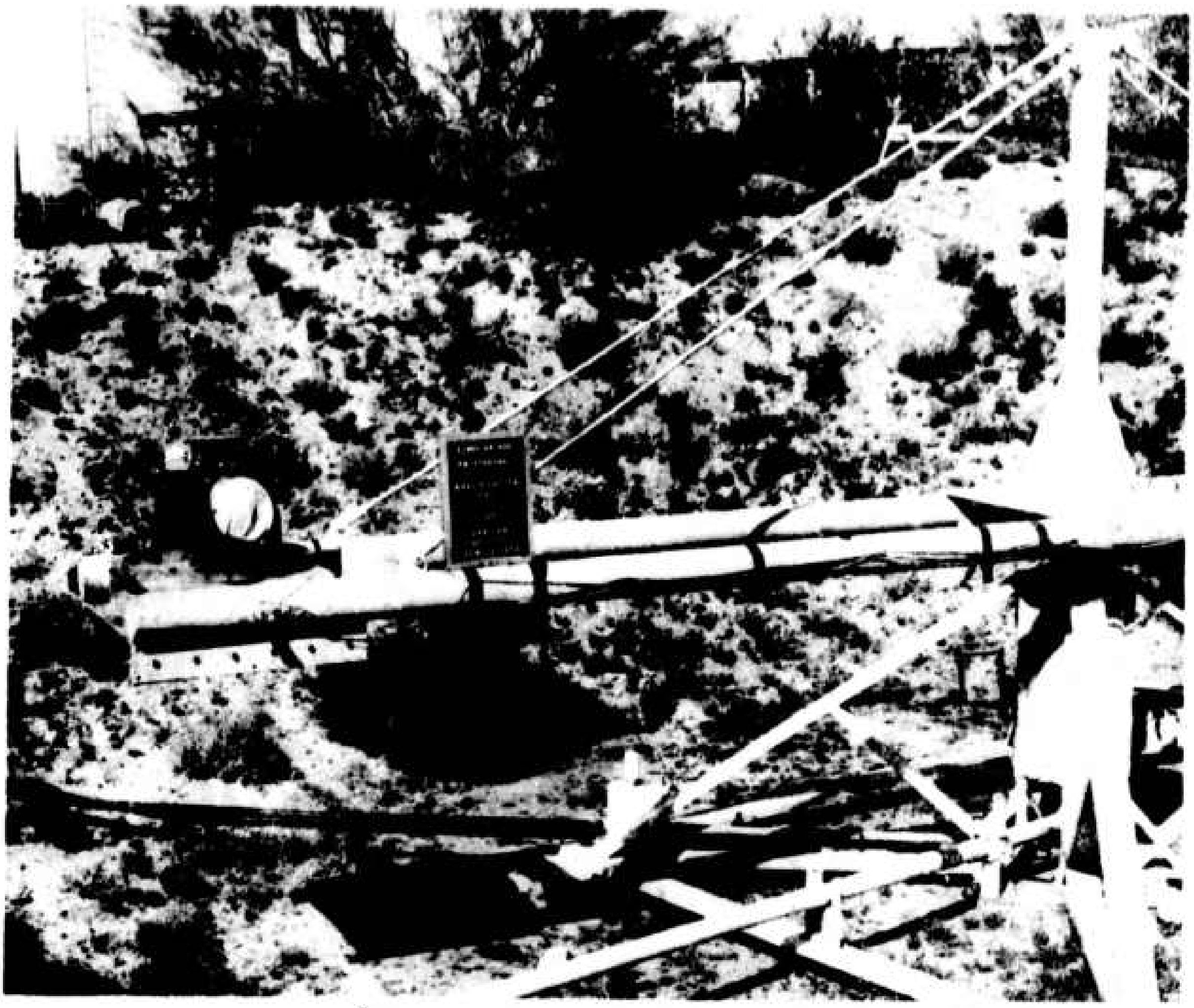


Figure 89. Engine Mounted on the Centrifuge in the Z-Axis.

5.7.2.5 Altitude Start

Following completion of the 10-hour 160°F soak, the engine was cartridge-started at a simulated altitude of 20,000 feet (hot day), Mach 0.60, with no inlet distortion. The start was successful, and the engine was run for 1 minute at the start condition (Condition No. 5). The required data scans were made, and the recording Traces No. 1 and 2 for IFRT No. 2 are contained in Section 6.4.

With the engine running at Condition No. 5, it was transitioned into its design point (Condition 4, tropical day, Mach 0.85 at sea level) in the following steps:

(a) Ram ΔP increased to 9.5 inches Hg. (Mach 0.90.)

(b) Inlet total temperature increased to 110°F

(c) Ram ΔP increased to 17.4 inches Hg. (Mach 0.85)

(d) Altitude reduced to Phoenix ambient

(e) Inlet total temperature final increase to 169°F

5.7.2.6 Design-Point Operation

The engine was run at the design-point until shut down due to a change in the engine thrust-bearing temperature. The engine accumulated a total run time of 26.2 minutes, with the performance and vibration levels being satisfactory throughout the test. Engine thrust was 3.7 percent below specification requirements during design-point operation. This was due to an inadvertent change in exhaust nozzle discharge coefficient. A complete discussion of this is presented in Paragraph 5.8.4.

The ball bearing temperature as a function of time is presented in Paragraph 5.8.3 herein. The vibration survey conducted during the test is presented in detail in Paragraph 5.7.3 herein. The corrected engine design-point performance data and log sheet for the test are contained in Section 6.4. The automatic recordings (Sanborn traces) were reduced for inclusion in this report and are contained in Section 6.4.

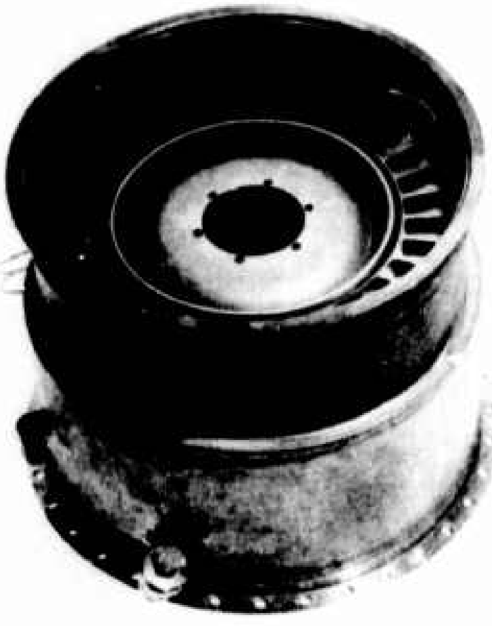
5.7.2.7 Disassembly and Inspection

IFRT Engine No. 2 was disassembled on April 4, 1973. The disassembly was witnessed by AiResearch Quality Control and NASC representatives. Each part was visually inspected, and the critical parts received a magnetic-particle or fluorescent-penetrant inspection. In addition, the critical parts were dimensionally checked, and the dimensions were recorded in the "AFTER" column on the Quality Control Reinspection Record cards. These cards and the teardown deficiency write-up data sheets are contained in Section 6.3.

The ball thrust bearing had experienced distress due to depletion of the lubricant supply. The ball elements were discolored due to high temperature, and the silver plate on the separator was worn on the outside diameter and in the ball pockets. This condition is shown in Figure 90-D.

The compressor rotor exhibited a typical loss of a portion of the abradable coating behind the third stage blades, as shown in Figure 91-A and considered acceptable after this endurance time.

All other parts were in excellent condition, as shown in Figures 90-A,-B,-C; 91-B,-C,-D; 92; and 93. The effective area of the combustor/nozzle assembly (see Figure 90-A,-B, and -C) was determined by a flow test to be 12.10 square inches. This is an increase of 1 percent over the 11.98 square inches measured before assembly and test of the engine. This variation is within acceptable limits.



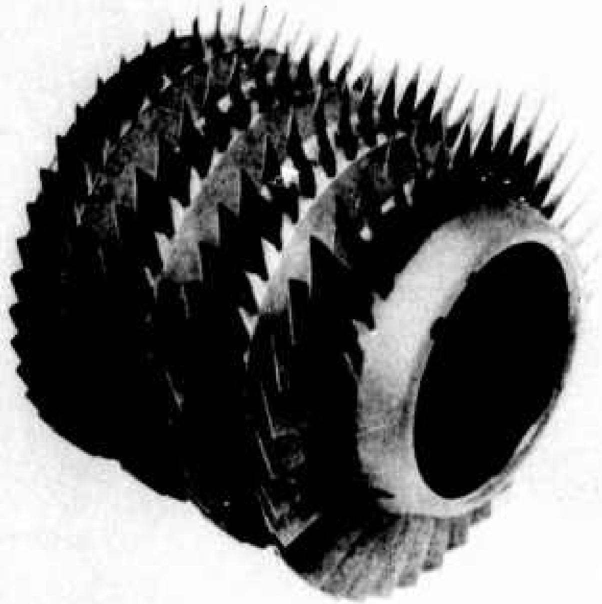
A. COMBUSTOR AND NOZZLE PART 3740292-3, SERIAL NO. 1480

B. COMBUSTOR AND NOZZLE PART 3740292-3, SERIAL NO. 1480

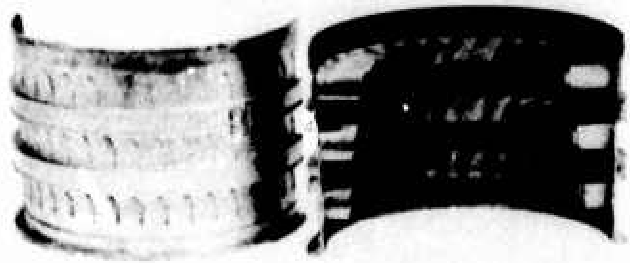
C. COMBUSTOR AND NOZZLE PART 3740292-3, SERIAL NO. 1480

D. THRUST BEARING AND SUPPORT PART 3740290-1, SERIAL NO 3-102.

Figure 90. IFRT Engine No. 2, Condition of Parts after 26 Minutes Endurance Run Time. Test Dates: March 30-April 4, 1973.

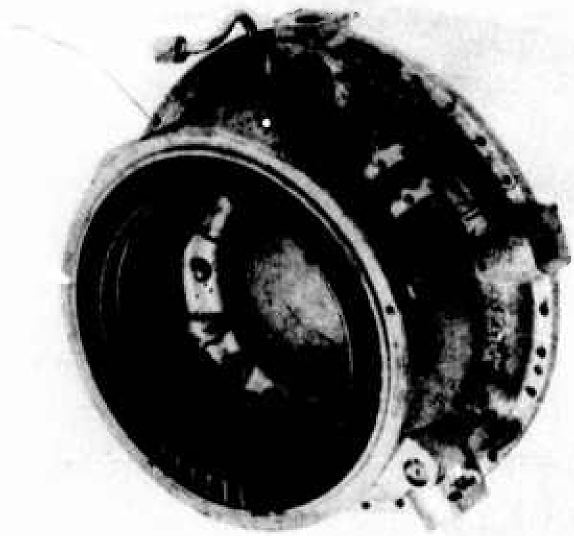


A. COMPRESSOR ROTOR PART 3740393-1
SERIAL NO. AC-23



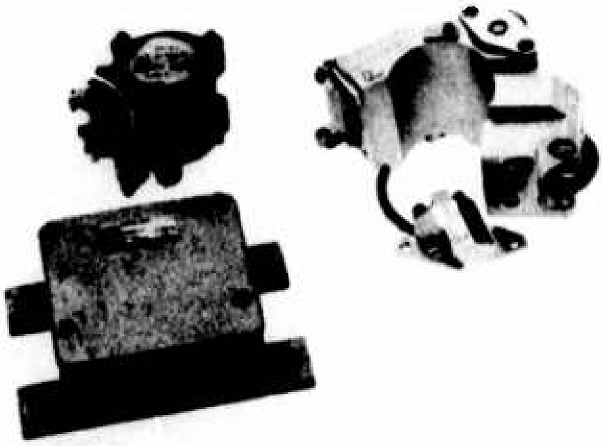
B. COMPRESSOR STATOR PART 3740270-2
SERIAL NO. 72X142

C. TURBINE ROTOR PART 3740283-3
SERIAL NO. 2646

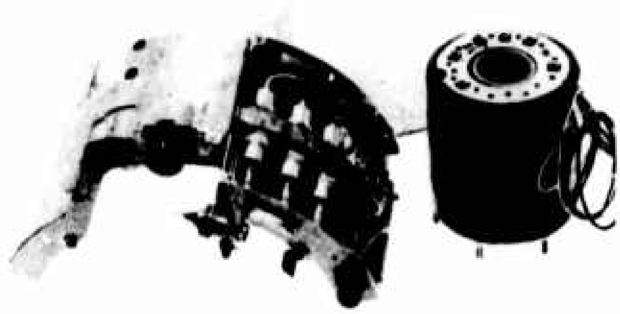


D. MIDFRAME PART 3740387-3
SERIAL NO. 72X113

Figure 91. IFRT Engine No. 2, Condition of Parts after 26 Minutes Endurance Run Time. Test Dates: March 30-April 4, 1973.



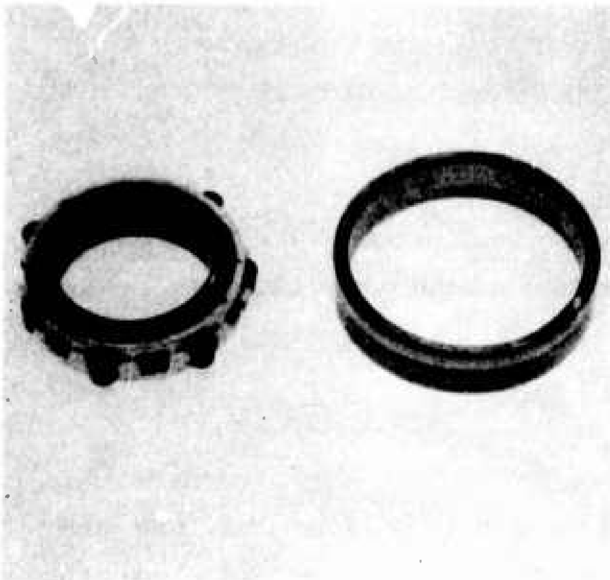
A. FUEL CONTROL SYSTEM

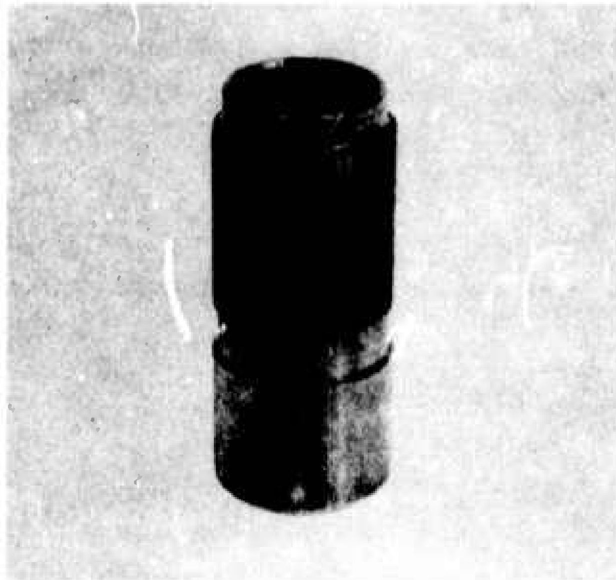


B. ELECTRICAL SYSTEM

C. STARTER PART 3505055-4

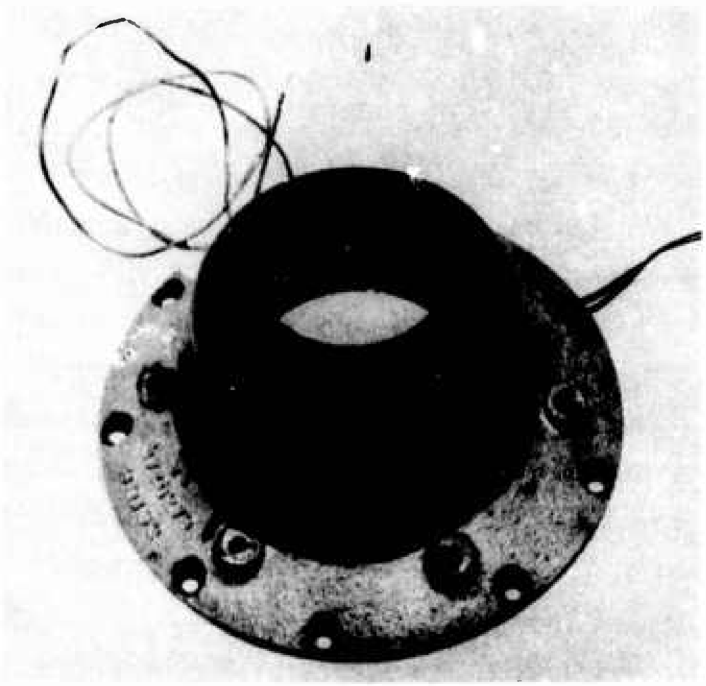
Figure 92. IFRT Engine No. 2, Condition of Parts after 26 Minutes Endurance Run Time. Test Dates: March 30-April 4, 1973.





A. ROLLER BEARING

B. FUEL-CONTROL DRIVE GEAR



C. FORWARD BEARING CARRIER

Figure 93. IFRT Engine No. 2, Condition of Parts After 26 Minutes Endurance Run Time. Test Sales: March 30-April 4, 1973.

Control system components were examined and tested on the bench following engine teardown, and the test points were within the required limits. Figure 94 shows the pre- and post-test calibration of the Fuel Metering Assembly Part 3740425-1, and Figure 95 shows the pre- and post-test calibration of the Pressure Control Valve Part 3740427. The wiring harness assembly also checked satisfactorily following the test. Data sheets of the pre- and post-test checks of the control-system components are contained in Section 6.4.

5.7.3 Vibration Survey

A vibration survey was conducted on each engine during the initial flight rating tests. The survey demonstrated compliance with the requirements that the compressor and turbine system be free from destructive vibration throughout the complete operating range of the engine. The vibrational characteristics of the compressor and turbine system are such that no fatigue cracks were present during the post-IFRT inspection.

Vibration was measured at the vibration sensor mounting point designated in the engine specification. The amplitudes of vibration as a function of time are shown in the automatic recording (Sanborn traces) Trace No. 1 for each engine, and are contained in Section 6.4. The vibration displacement units are in mils (1 mil = 0.001 inch double amplitude). The characteristics of this vibration were further investigated through the use of a frequency analyzer. The vibration signal was reduced to show the major frequency components that were present, as shown in Figures 96 and 97 for IFRT No. 1 and in Figures 98 and 99 for IFRT No. 2. The vertical scale is in mils, and the horizontal is frequency in cycles per second (Hertz).

For both tests, the major vibratory frequency was at shaft speed. During IFRT No. 1, a subsynchronous frequency appeared at

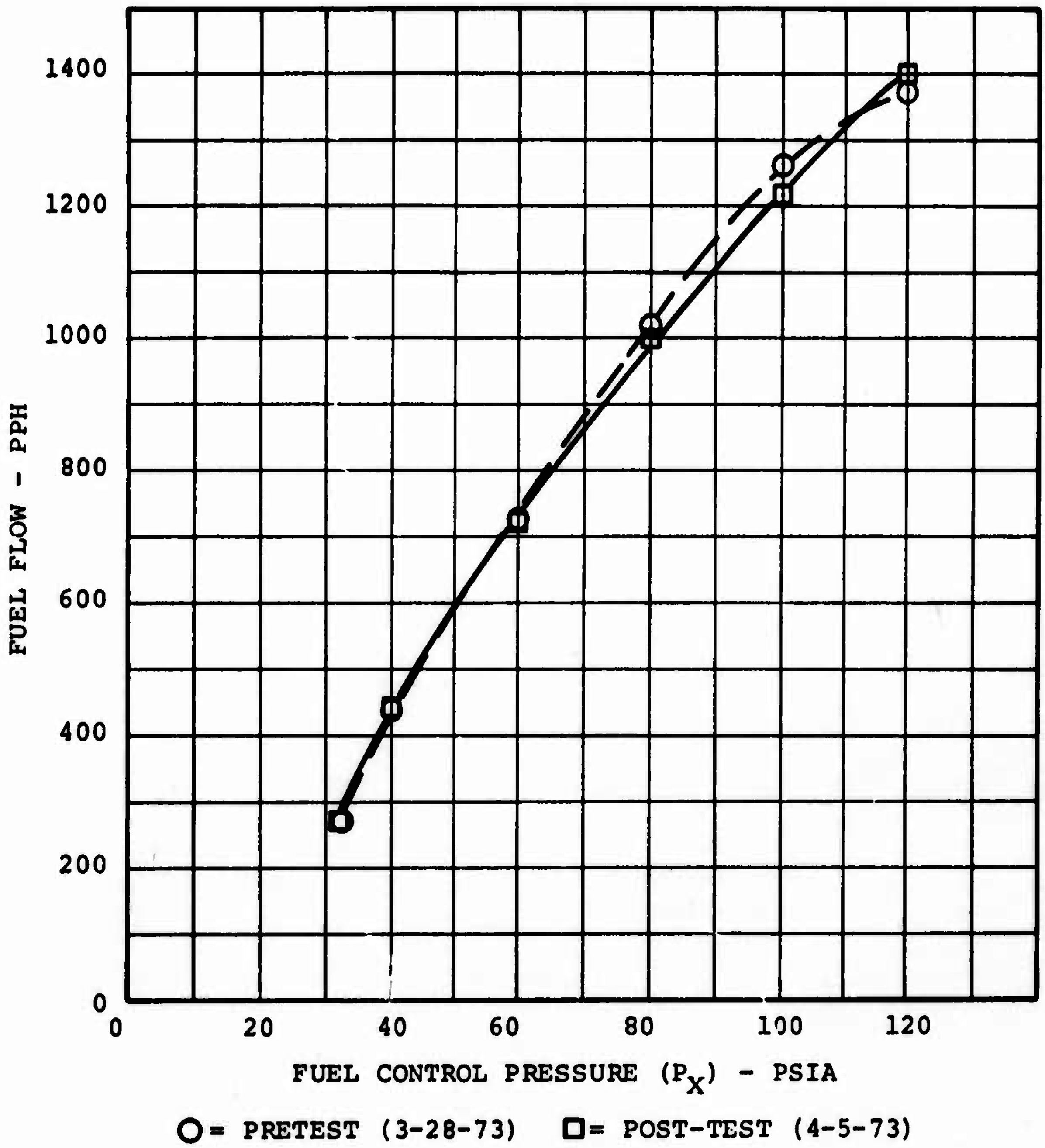


Figure Calibration Results of the Fuel Metering Assembly Part 3740425-1, Serial No. 2274-3 (IFRT Engine No. 2).

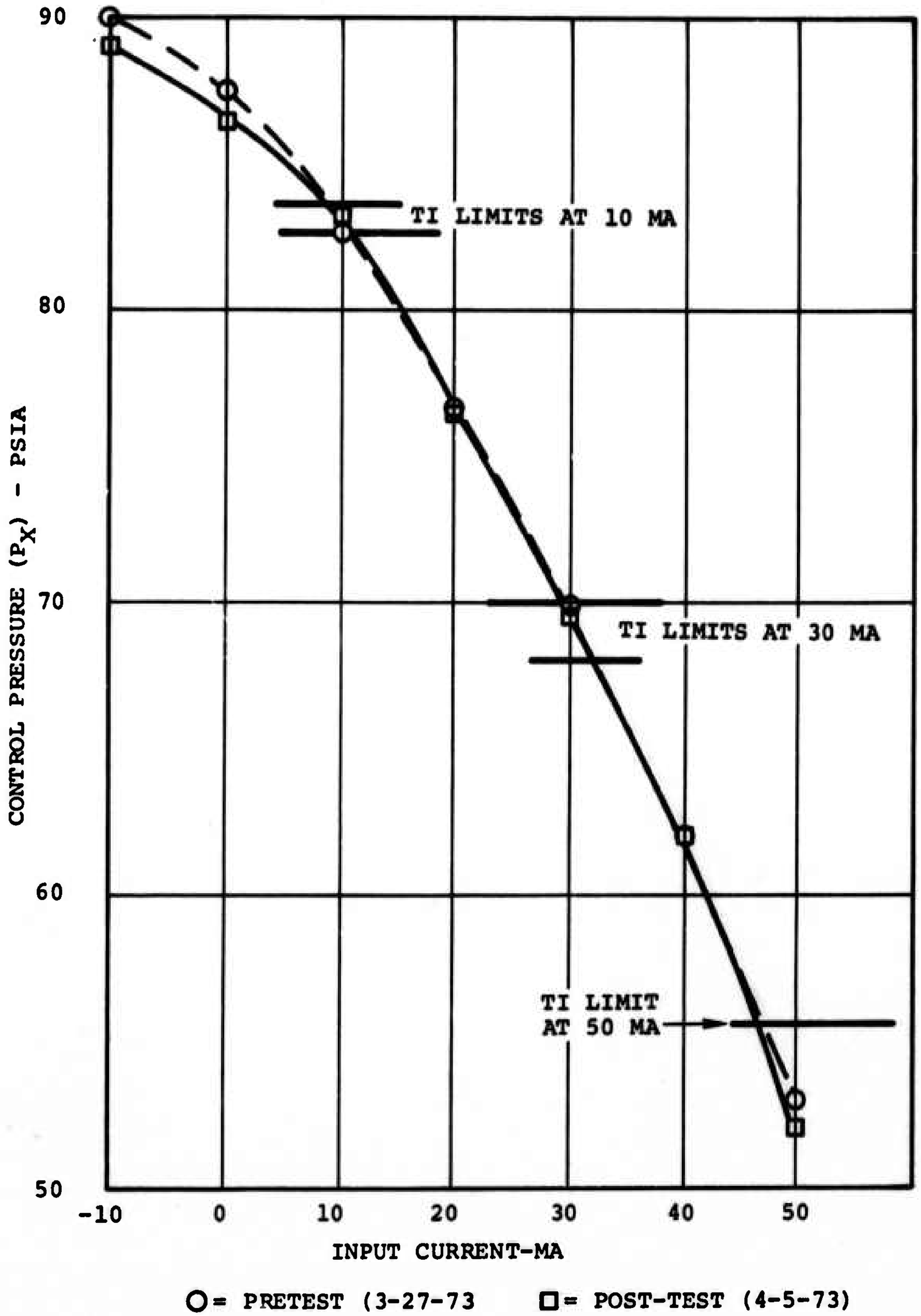
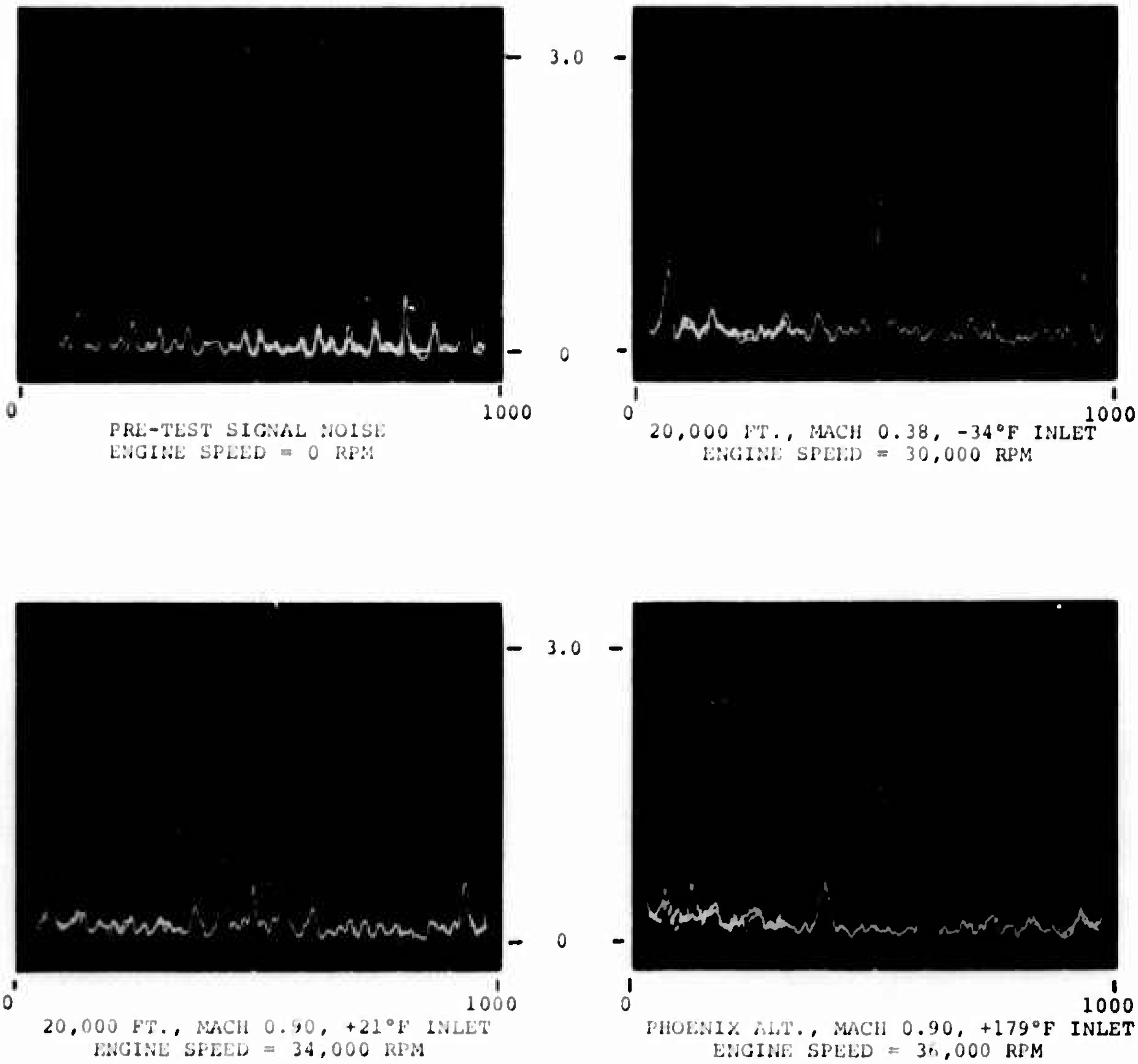


Figure 95. Calibration Results of the Pressure Control Valve Part 3740427-1, Serial No. 011 (IFRT Engine No. 2).



VERTICAL

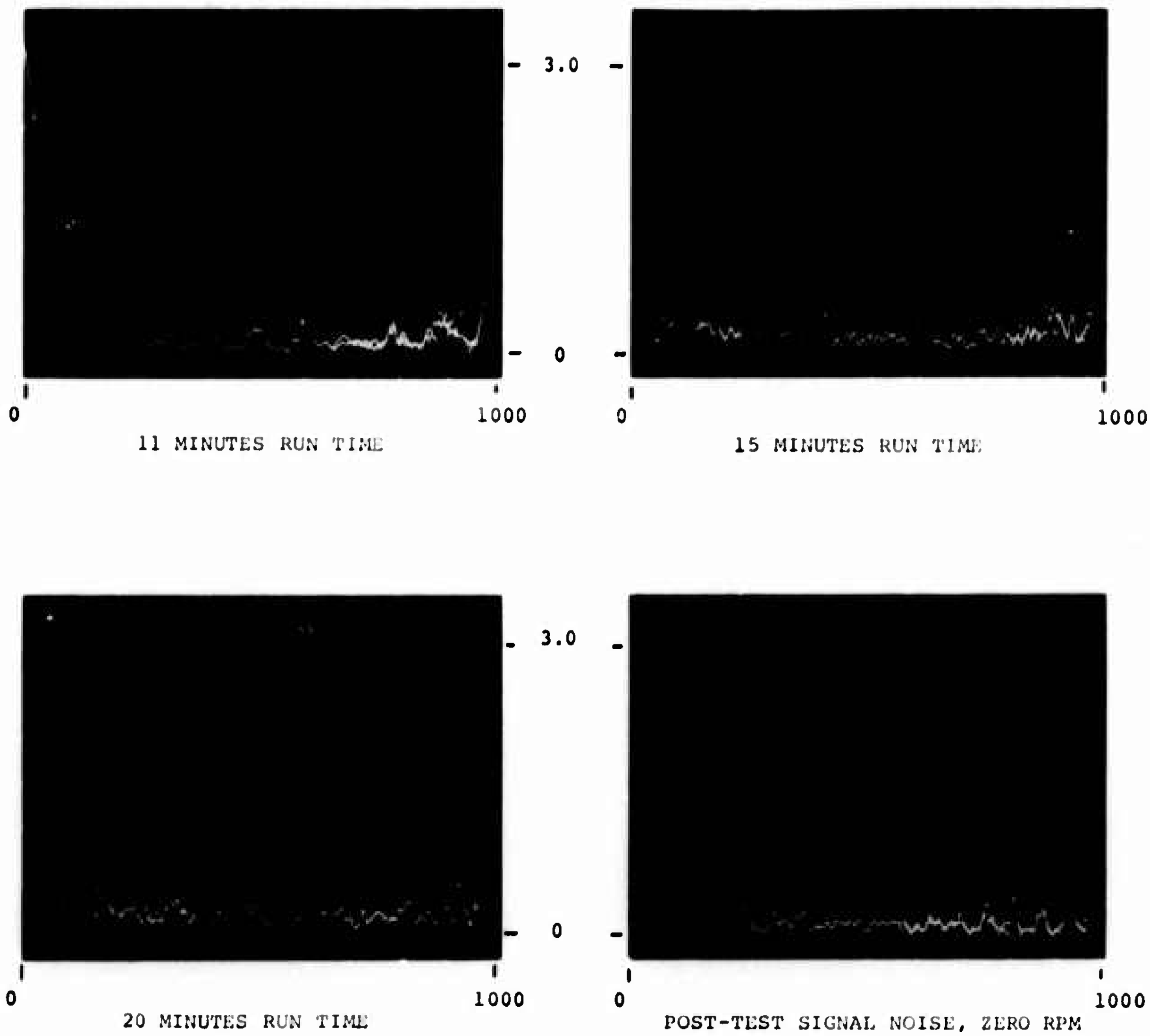
DOUBLE AMPLITUDE - 0.5 MILS/CM

HORIZONTAL

FREQUENCY - 100 HZ/CM

Figure 96. Vibration Survey IFRT No. 1.

MP-37767



ENGINE SPEED = 36,000 RPM
ALTITUDE = PHOENIX
MACH NO. = 0.85
INLET TOTAL TEMPERATURE = +169°F

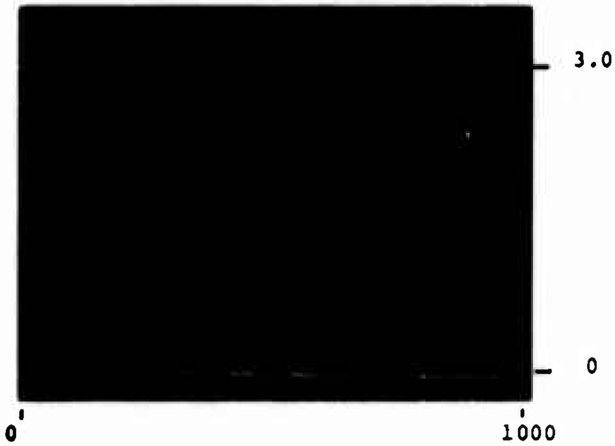
VERTICAL

DOUBLE AMPLITUDE - 0.5 MILS/CM

HORIZONTAL

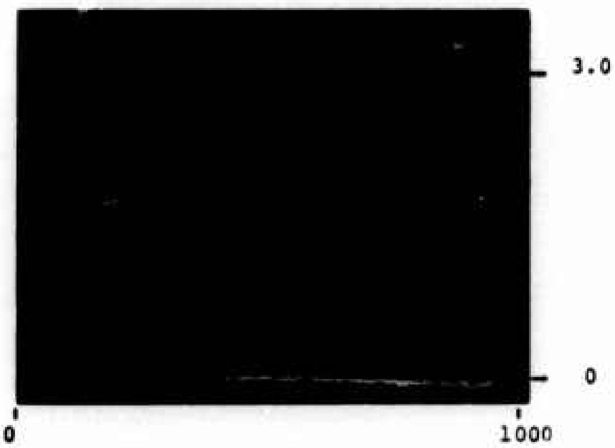
FREQUENCY - 100 HZ/CM

Figure 97. Vibration Survey IFRT No. 1.



20,000 FT., MACH 0.60, +60°F INLET
ENGINE SPEED = 31,000 RPM

20,000 FT., MACH 0.60, +60°F INLET
ENGINE SPEED = 31,000 RPM



10,000 FT., MACH 0.85, + 110°F INLET
ENGINE SPEED = 35,000 RPM

PHOENIX ALT., MACH 0.85, 110°F INLET
ENGINE SPEED = 35,000 RPM

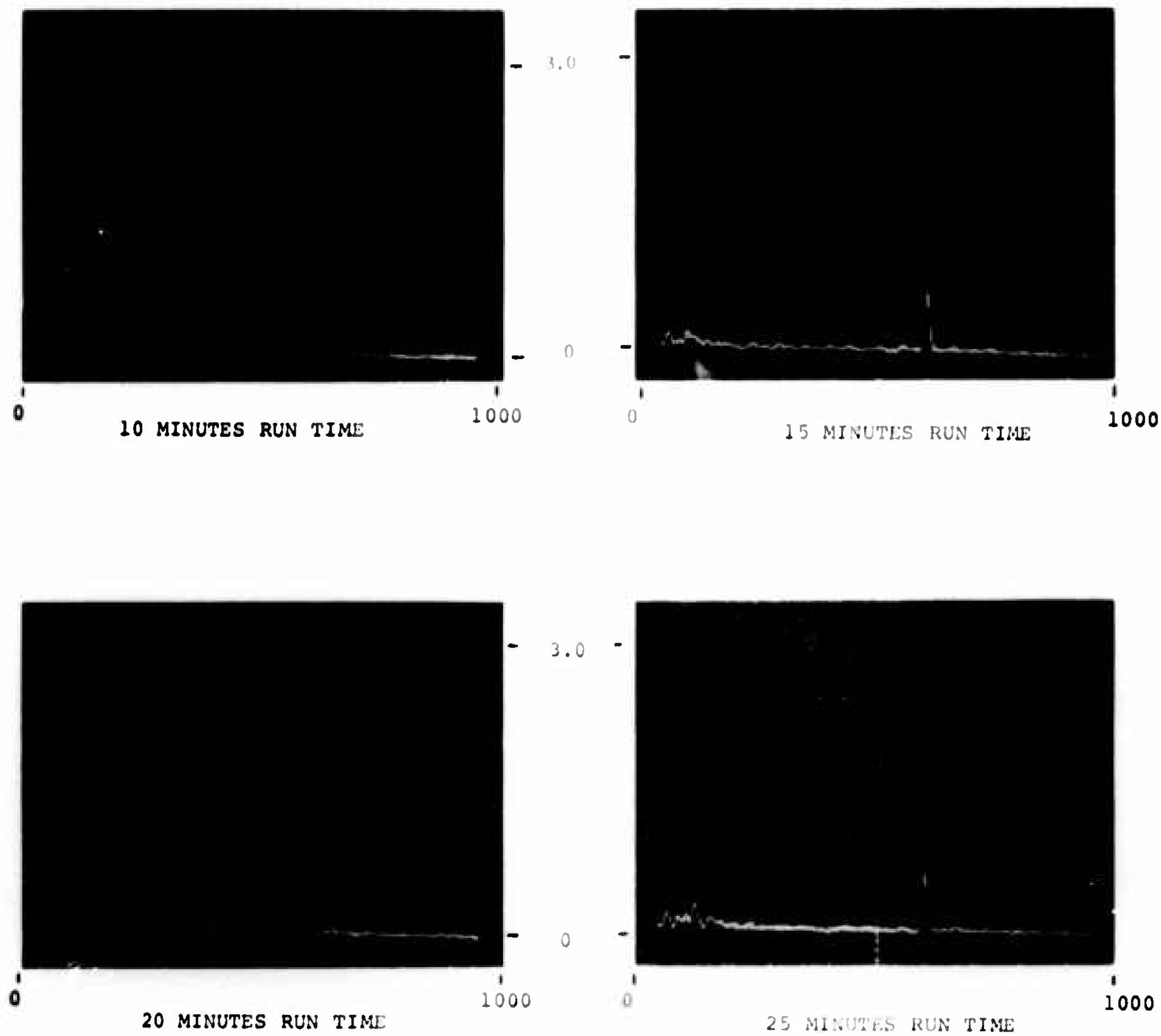
<u>VERTICAL</u>

DOUBLE AMPLITUDE - 0.5 MILS/CM

<u>HORIZONTAL</u>

FREQUENCY - 100 HZ/CM

Figure 98. Vibration Survey IFRT No. 2.



ENGINE SPEED = 36,000 RPM
ALTITUDE = PHOENIX
MACH NO. = 0.85
INLET TOTAL TEMPERATURE = +169°F

VERTICAL

DOUBLE AMPLITUDE - 0.5 MILS/CM

HORIZONTAL

FREQUENCY - 100 HZ/CM

Figure 99. Vibration Survey IFRT NO. 2.

approximately two-thirds of shaft speed. During IFRT No. 2, there were no significant frequencies other than shaft speed.

5.8 Supplemental IFRT Data

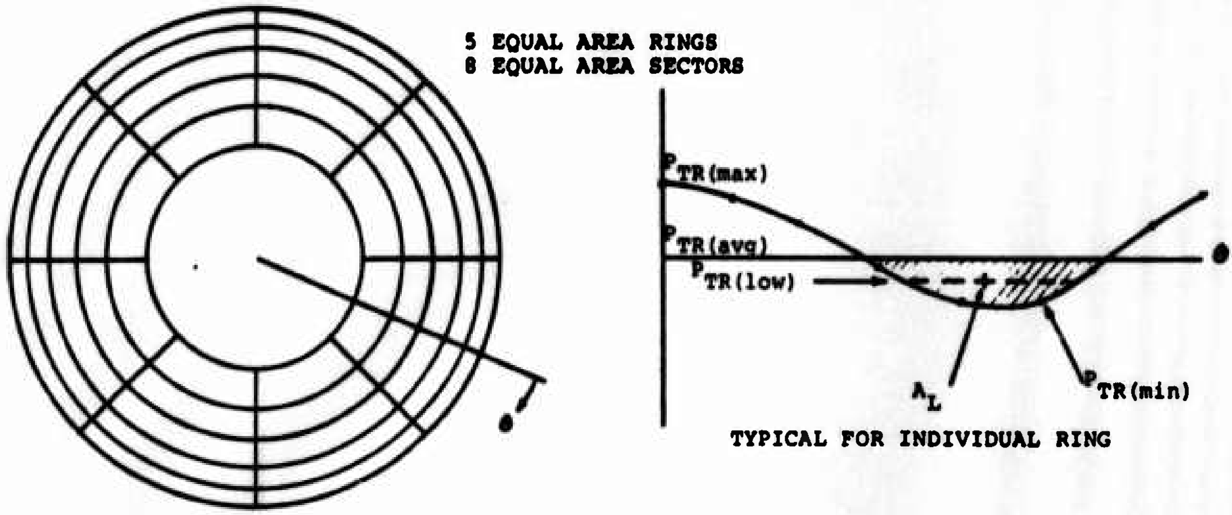
5.8.1 Circumferential Distortion Index (CDI)

The blockage screen used to produce the inlet air total pressure distortion pattern for testing of IFRT engine No. 1 is a semicircular screen made of 0.012-inch-diameter wire spaced 24 wires per inch in a square mesh (see Figure 75). This screen was installed between the cell inlet plenum and the transition duct ahead of the engine inlet.

The distortion pattern produced by the screen was measured during the test, by means of eight 5-element total pressure rakes installed in the transition duct at a plane 5 inches ahead of the leading edge of the first-stage compressor vanes. The rakes were circumferentially equally spaced. The five pressure probes on each rake were radially located so that each probe was centered in one of the five equal-area rings. The method of calculating the CDI from the total pressure measurements is shown in Figure 100. The CDI measured during design-point operation was 12.4 percent. The computer output for the CDI calculations is shown in Figure 101.

5.8.2 Non-Operation of Ignitors

The initial altitude start attempt on IFRT Engine No. 1, was not successful due to human error. Although the engine was accelerated properly by the cartridge starter, the pyroflare ignitor did not operate. The source of the problem was determined to be miswiring of the pyroflare ignitor to an electrical connector. The ignitor was miswired in such a manner that each of the bridgewires was short circuited to one pin of the connector.



LAYOUT OF 40 EQUAL AREA PRESSURE MEASUREMENTS

TYPICAL FOR INDIVIDUAL RING

$$\mathrm{CDI} = \frac{P_{TR(max)} - P_{TR(min)}}{P_{TR(avg)}} \sqrt{S \times \frac{2A_L}{A_R}}$$

$$\mathrm{RDI} = \frac{\bar{P}_{TR(max)} - \bar{P}_{TR(min)}}{P_{T(avg)}}$$

Where:	A_L	= Continuous portion of A_R wherein the measured total pressures are less than $P_{TR(avg)}$
	A_R	= Annulus area of ring at distortion measurement plane
	$P_{T\ (avg)}$	= Average total pressure at the distortion measurement plane (all rings)
	$P_{TR(avg)}$	= Average total pressure of ring under consideration
	$P_{TR(max)}$	= Highest total pressure in ring under consideration
	$P_{TR(min)}$	= Lowest total pressure in ring under consideration
	$P_{TR(low)}$	= Area weighted average total pressure in A_L of ring under consideration
	$\bar{P}_{TR(max)}$	= Maximum $P_{TR(avg)}$ for all rings
	$\bar{P}_{TR(min)}$	= Minimum $P_{TR(avg)}$ for all rings
	S	= Shape factor = $\frac{\pi}{2}\left[\frac{P_{TR(avg)} - P_{TR(low)}}{P_{TR(avg)} - P_{TR(min)}}\right]$

Figure 100. Numerical Procedure for Calculating Circumferential and Radial Distortion Indices (CDI and RDI).

XJ401-GA-400 LACC#2 04/07/73 IFRT#1 ORIG/1 ATP   POINT NO. 1   TIME IS 12:36:37

OUTER RADIUS = 4.18   INNER RADIUS = .00   TIP RADIUS = .00   HUB RADIUS = .00
TOTAL PRESS. = .0000   REFERENCE PRESS. = .0000

TABLE OF PRESSURES (OR RATIOS)

RAKE ANGLE / RADII =	1.323	2.292	2.959	3.501	3.970
22.500	1.692	.000	1.709	1.716	.000
67.500	1.677	1.672	1.707	1.692	.000
112.500	1.540	1.546	1.540	1.538	1.530
157.500	1.547	.000	1.538	1.544	1.531
202.500	1.537	1.538	1.536	1.539	1.527
247.500	1.541	1.536	1.536	1.535	1.527
292.500	1.684	1.688	1.677	1.664	1.685
337.500	1.685	1.662	1.727	1.661	1.630

TABLE OF EQUAL AREA PRESSURES

RAKE ANGLE / RADII =	1.323	2.292	2.959	3.501	3.970
22.500	1.692	1.701	1.709	1.716	1.723
67.500	1.674	1.684	1.692	1.699	1.705
112.500	1.540	1.545	1.543	1.537	1.530
157.500	1.546	1.545	1.542	1.538	1.534
202.500	1.537	1.539	1.537	1.534	1.529
247.500	1.541	1.538	1.535	1.532	1.529
292.500	1.687	1.680	1.677	1.677	1.678
337.500	1.676	1.698	1.688	1.666	1.637

RING	E	S	DELTAP/P	CDI	NO. OF LOWS
1	1.005	1.293	.096	.110	1
2	1.016	1.301	.101	.116	1
3	1.013	1.299	.107	.123	1
4	1.005	1.319	.114	.131	1
5	.994	1.349	.121	.140	1

PT FACE AVG. = 1.613   DISTORTION = .124   RDI = .005   CDIAV = .124

Figure 101. Computer Output Data for CDI Calculations for IFRT No. 1

A second start attempt was aborted when the starter grain did not ignite. Examination of the starter and its ignitor showed that the ignitor had fired, but with insufficient intensity to penetrate the foil covering over the starter cartridge. The defective ignitor was from a new lot, number HLX-2-9. Inspection of several other ignitors from the same lot revealed poor bonding of the Mylar seal over the end of the ignitor. The purpose of the Mylar seal is to allow the burning ignitor to build up sufficient pressure for rapid combustion. The probable cause of the aborted start was failure of the poorly bonded Mylar disc to seal properly, resulting in slow burning of the ignitor rather than a high energy explosion.

A new ignitor was selected and installed after several had been rejected by visual inspection. The start was then accomplished successfully.

5.8.3 Thrust Bearing Temperature Slope

During IFRT tests and preliminary IFRT testing, the engine thrust bearing temperature was continuously monitored and automatically recorded. When the bearing temperature indicated a sudden increase, while on the endurance condition, the test was terminated by an engine shutdown. Figure 102 is a plot of the thrust bearing temperature as a function of time, showing the slope of the temperature increase for IFRT Engines No. 1 and 2 and preliminary IFRT Engines Serial No. 3301 and 3302.

5.8.4 Exhaust Nozzle Effective Area Change

During the design-point operation portion of IFRT No. 2 it was noted that engine thrust was approximately 6 percent lower than the thrust level set during the acceptance test. The cause of the reduced thrust was determined to be due to a difference in starters

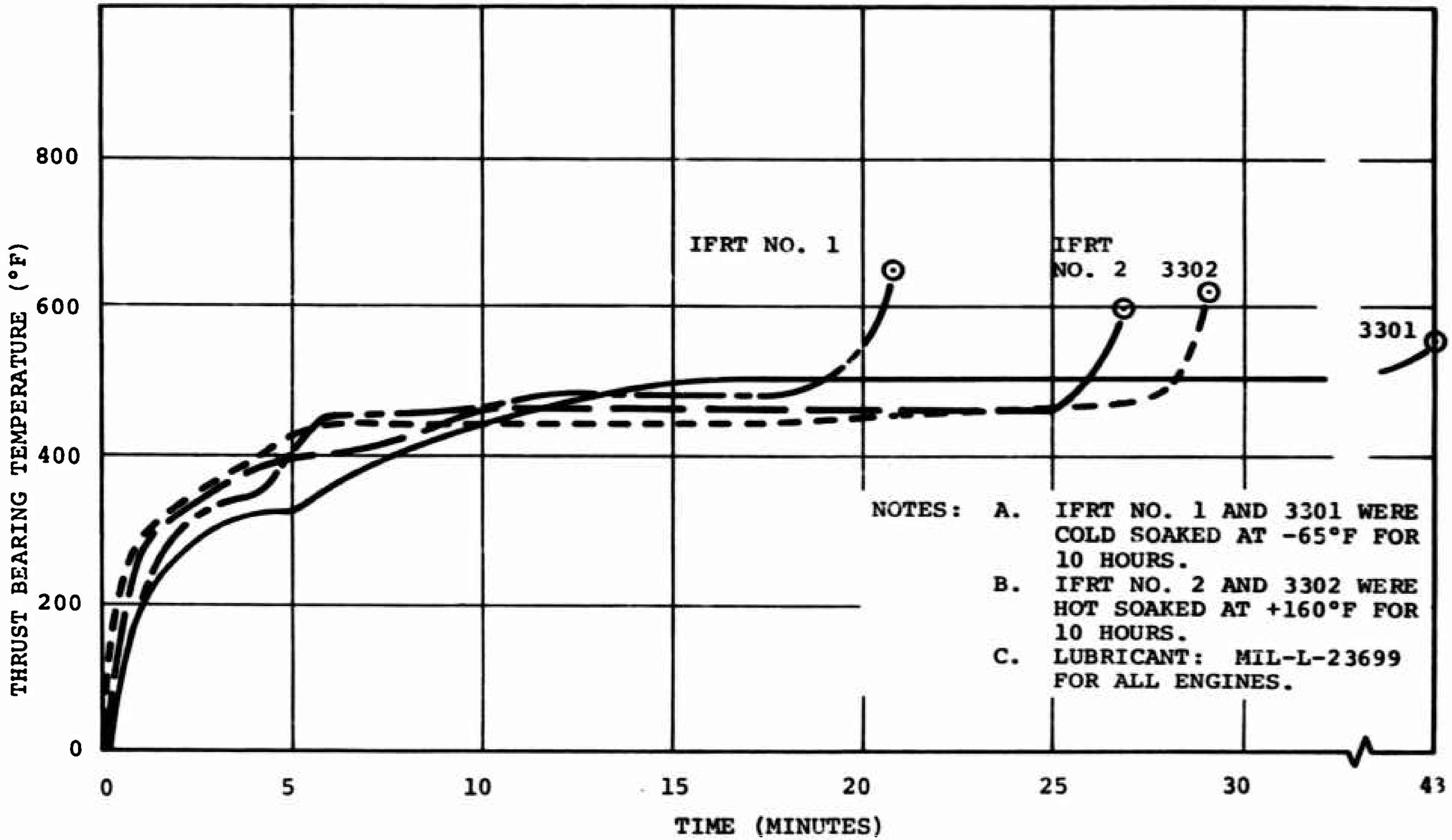


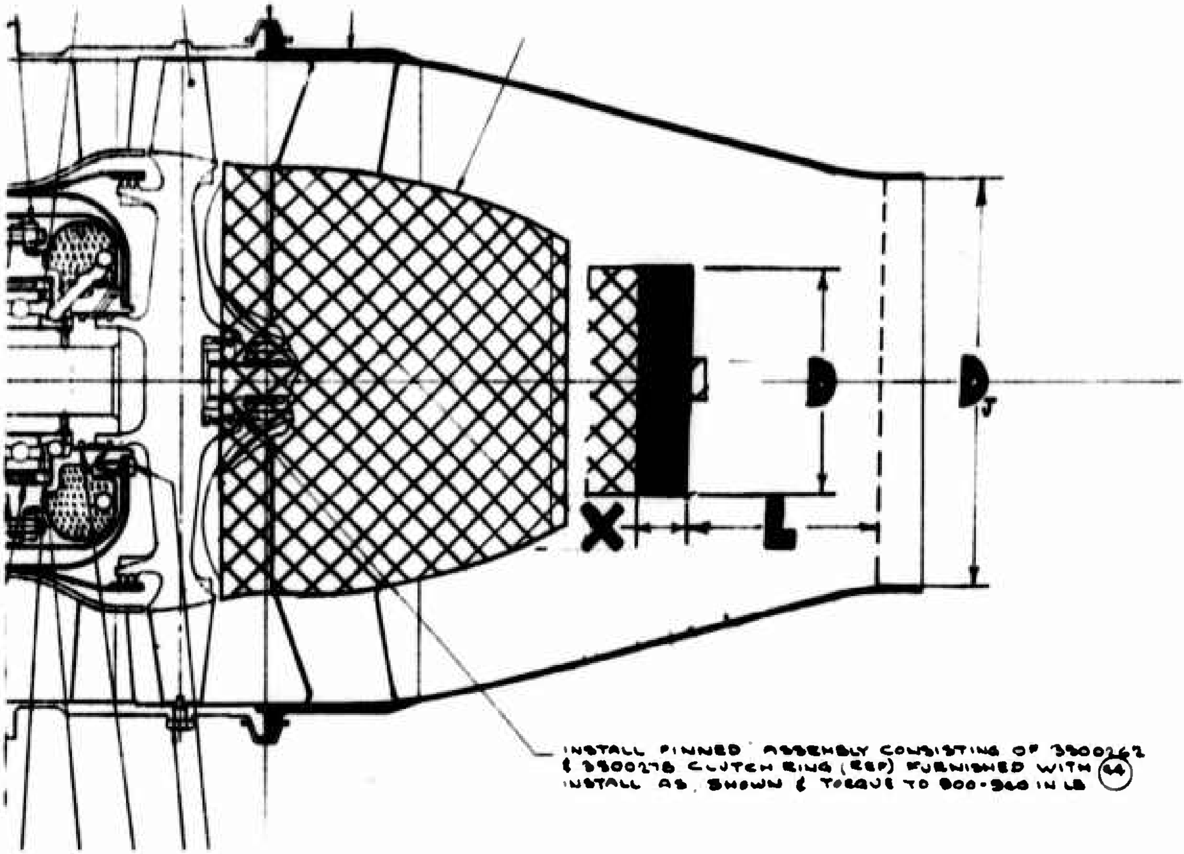
Figure 102. Thrust Bearing Temperature as a Function of Time for IFRT Engines.

between that used in acceptance testing and the starter used for the IFRT. This resulted in an effective area change in the exhaust thrust nozzle. The effect was the same as setting the engine speed during acceptance test to provide specification thrust with a small thrust nozzle, and then changing the nozzle for the IFRT to a larger size, without changing the engine speed setting.

A post-test investigation revealed that the ring gear on the "dummy" starter used for acceptance testing had become dislocated from its normal position and was shifted approximately 0.75 inch aft. The ring gear in the shifted position is represented in Figure 103 by the solidly shaded area. It was subsequently demonstrated, both analytically and by tests, that this shift was the cause of the difference in performance between the acceptance test and the IFRT.

With use of the geometric data from Figure 103, the change in discharge coefficient was determined from the curves of Figure 104 (these curves were plotted from model test data). It was analytically determined that the ring gear shift caused a 1.2-percent decrease in the flow coefficient of the exhaust nozzle. Inserting this new value of flow coefficient into the engine performance computer program resulted in a calculated change in thrust of approximately 5 percent. This calculation agreed very closely with the performance change seen between acceptance test and IFRT.

An engine test was performed to verify the analysis of the results of IFRT engine No. 2. The test results agreed with the analytical predictions. For this test, a development engine was installed in the same facility used for the IFRT. The tailpipe from the IFRT was used with the facility "dummy" starter, and the ring gear was retained by weldments 0.75 inch aft of its normal position. This was the same "dummy" starter used in the acceptance test of IFRT engine No. 2. The test was conducted at Phoenix altitude with a total inlet air temperature of 50°F, at Mach 0.85, as agreed to by NASC representatives in



- D_J ~ EXIT JET DIAMETER 5.92 IN
- D ~ DIFFUSER DUMP DIA. 3.35 IN
- L ~ SPACING 3.60 IN. NOMINAL
- X ~ RING GEAR SHIFT 0.75 IN. APROXIMATE

	NOMINAL POSITION	SHIFTED POSITION
L/D_J	0.61	0.47
D/D_J	0.57	0.57

Figure 103. Ring Gear Shift on IFRT Engine No. 2.

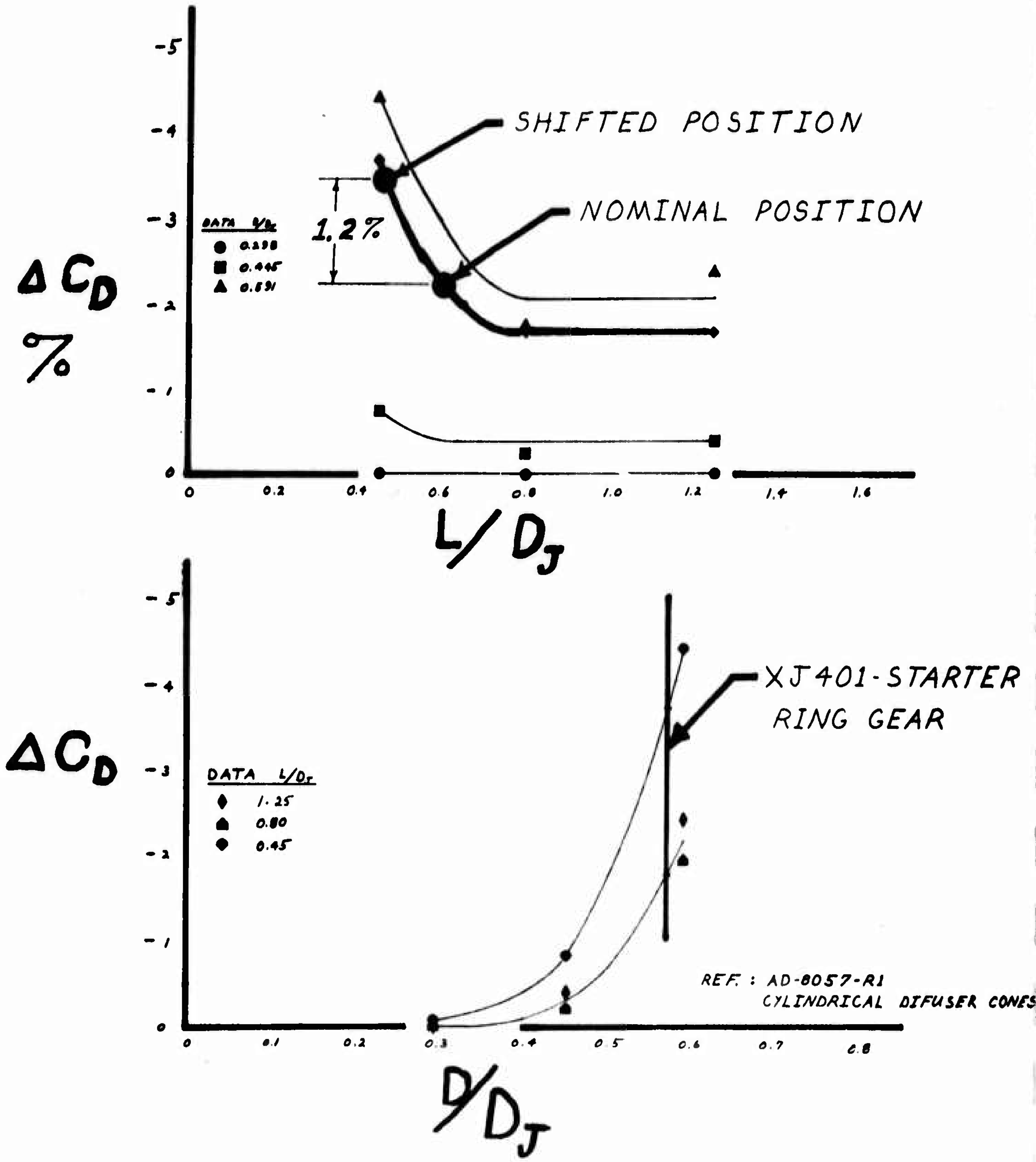


Figure 104. Exhaust Nozzle-Diffuser Interactions (IFRT Engine No. 2).

Phoenix on April 11, 1973. The engine speed was set to 32,000 rpm, and the performance data was recorded by computer.

Following the test the engine was shut down and the "dummy" starter was removed. The cartridge starter from IFRT engine No. 2, with the ring gear located normally, was then installed on the engine. With this being the only change to the engine, the above-described test was repeated. The data was reduced by the computer, and the results summarized in Table XVI, showed that the change in thrust noted during IFRT was caused by the changes in starter from the acceptance test to the IFRT.

TABLE XVI. EXPERIMENTAL VERIFICATION OF THE PERFORMANCE EFFECTS OF EXHAUST NOZZLE EFFECTIVE AREA CHANGE.

TEST CONDITIONS

Altitude = Phoenix (1050 feet)
Inlet total temperature = 50°F
Engine speed = 32,000 $^{+0}_{-60}$ rpm

	Analytical Prediction			Test Results		
	Ring Gear Aft	Ring Gear Normal	Δ	Ring Gear Aft	Ring Gear Normal	Δ
F_n, lb	547	520	5%	552	519	6%
W_f, lb/hr	807	767	5%	838	794	5%
Calculated T_{t7}, °F	1148	1096	52°F	1254	1185	69°F
Calculated T_{t4}, °F	1427	1375	52°F	1527	1462	65°F
P_{t7}/P_{am}	2.84	2.75	0.09	2.78	2.70	0.08
C_D	0.956	0.970	0.014	0.916	0.934	0.018

6.0 DOCUMENTS AND DATA

6.1 Test Item Definition

This section contains the assembly traveler and the parts list for each engine. The item and page numbers are as follows:

Item	IFRT Engine No.	Page
Assembly traveler	1 and 2	176
Parts list	1 and 2	177 - 190

FR11-2-4C AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

ASSEMBLY INSPECTION TRAVELER Traveler No. ORIG

OUTLINE	C/L	MODEL	SERIES	SERIAL NUMBER
3740300-1		XJ411-6A-NW	1	1FRT #1

ASSEMBLY NO	C/L	DESCRIPTION	CUSTOMER
3740301-1	F	TURBOJET ENGINE ASSY	

START DATE	CURE DATE	RELEASE OR S.O. NUMBER	WEIGHT	DRY
4-3-73	NONE	3749-411017-[illegible]-0114	151	

PRODUCTION ☐ OVERHAUL ☐ REPAIR ☐ MILITARY ☐ COMMERCIAL ☐ 1FRT ☒

H.O.T. NUMBER	OP. NO.	ASSY NO.	RECORD DIMENSION	INSP STAMP	PART NUMBER	LOT NO.	SERIAL NO.	REQ'D	INSP. STP.
3741301-1	A	5202			3740283-1		S/N 958		
	B	5202			3740393-1		AC-17		
	C	5202							
	D	5202							
	E	5202							
	F	5202							
	G	5202							
	H	5202							
	J	5202							
	K	5202							
	L	5202							
	M	5202							
	N	5202							
	P	5202							
	R	5202							
PRE LAB	S	5202							

DATE 4-4-73 ASSEMBLY SIGNATURE W E Rand 5202 INSPECTION STAMP SIGNATURE [illegible]

FR11-2-4C AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

ASSEMBLY INSPECTION TRAVELER Traveler No. ORIG

OUTLINE	C/L	MODEL	SERIES	SERIAL NUMBER
3740300-1		XJ401-CA-NW	1	1FRT #2

ASSEMBLY NO	C/L	DESCRIPTION	CUSTOMER
3740301-1	F	TURBOJET ENGINE ASSY	

START DATE	CURE DATE	RELEASE OR S.O. NUMBER	WEIGHT	DRY
3-31-73	NONE	3749-411019-24-1200	154.5	

PRODUCTION ☐ OVERHAUL ☐ REPAIR ☐ MILITARY ☐ COMMERCIAL ☐ 1FRT ☒

H.O.T. NUMBER	OP. NO.	ASSY NO.	RECORD DIMENSION	INSP STAMP	PART NUMBER	LOT NO.	SERIAL NO.	REQ'D	INSP. STP.
3740301-1	A	5206			3740283-1		2645		
	B	5202			3740393-1		AC-23		
	C	5202			316100-1-1		P-105		
	D	5202							
	E	5202							
	F	5202							
	G	5202							
	H	5202							
	J	5202							
	K	5202							
	L	5202							
	M	5202							
	N	5202	.010						
	P	5202							
	R	5202							
PRE LAB	S	5202							

DATE 3/31/73 ASSEMBLY SIGNATURE W E Rand 5202 INSPECTION STAMP SIGNATURE [illegible]

PARTS LIST	GARRETT	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	TITLE	PL 3740301	PL REV V
	D	CODE IDENT NO. 99193 · APPROVAL [illegible] · ORIGINAL ISSUE [illegible] 9, 1972	ENGINE ASSY. TURBOJET, EXPENDABLE	SECTION · SHEET 1 OF 13 SHEETS	DWG REV N

REVISION STATUS EACH SHEET

REV	V	V	S	U	K	D	E	K	U	G	U	N	T												
SHT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
REV																									
SHT	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
REV																									
SHT	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75
REV																									
SHT	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
REV																									
SHT	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125

USE CODE

1. VENDOR ITEM - SEE CONTROL DWG
2. SPARE PART OR ASSY - SEE DWG
3. CUSTOMER FURNISHED ITEM

REVISION CODE

1. CHANGED ZONE OR SHEET NO.
2. CHANGED NOMENCLATURE
3. CHANGED DRAWING REV LTR
4. GENERAL CHANGE SEE E.O.

REVISION HISTORY THIS SHEET

	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
D	A	ENGR	1-17-72												
D	B	ENGR	[illegible]												
D	C	ENGR	5-26-72												
D	D	ENGR	6-26-72												
D	E	ENGR	7-5-72												
D	F	ENGR	7-12-72												
D	G	ENGR	9-10-72												
D	H	ENGR	10-16-72												
D	J	ENGR	10-27-72												
D	K	ENGR	11-17-72												
	L	INC. ADCEO	11-24-72												
	M	INC. ADCEO	11-30-72												
D	N	ENGR	12-5-72												
D	P	ENGR	1-5-73												
D	R	ENGR	1-23-73												
D	S	ENGR	2-7-73												
D	T	ENGR	2-16-73												
D	U	ENGRG	3-6-73												
D	V	ENGR	3-27-73												

CONTRACT NO.

PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	TITLE	PL 3740301	PL REV
	CODE IDENT NO 99193 · ORIGINAL ISSUE MARCH 9, 1972	ENGINE ASSY, TURBOJET, EXPENDABLE	SECTION · SHEET 2	V

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	-1							REV CODE	REV LTR
1	—	—		3740301-1	ENGINE ASSY		X							3	U
2	1	G13		3740388-4	MID FRAME ASSY, SET, MATCHED		1							4	V
3	1	C16		NDC 3740300-1	PLATE, IDENT		1								
4	1	G12		3740280-1	SHIELD, MID FRAME		1								
5															
6	1	E16		3740326-1	CLAMP HALF, BAND, SPECIAL		1							4	E
7	1	G12		2045042-2-1	ALTERNATOR		1							4	G
8	1	E2		3740322-1	NUT, SPL		2								
9														4	G
10														4	K
11	1	D2		3740317-1	BUS BAR, ALTNTR		1								
12	1	E4		3740318-1	BUS BAR, ALTNTR		1								
13	1	C3		3740319-1	BUS BAR, ALTNTR		1								

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72	V	ENGR	11-13-72									
D	ENGRG	6-26-72		ENGR	1-5-73									
E	ENGRG	7-5-72	U	ENGRG	3-6-73									
G	ENGR	9-20-72	V	ENGRG	3-27-73									

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PARTS LIST

AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

CODE IDENT NO. 99193

ORIGINAL ISSUE March 9 1972

TITLE ENGINE ASSY, TURBOJET, EXPENDABLE

PL 3740301

SECTION

SHEET 3

PL REV S

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1	REV CODE	REV LTR
14	1	B12		3740290-1	BEARING	1	1		
15								4	G
16	1	G12		3740292-3	COMBUSTOR AND NOZZLE		1	4	S
17	1	B11		3740337-1	BOLT, PIN RTNG		1	4	H
18	1	B12		3740398-1	SPACER		1	4	G
19	1	B14		3740381-1	SLINGER, OIL		1	4	G
19								4	G
20	1	B11		3740468-1	SLINGER, OIL		1	4	R
21	1	B14		3740289-1	SPACER		A/R		
22	1	B14		3740289-2	SPACER		A/R		
23	1	B14		3740289-3	SPACER		A/R		
24	1	B14		3740289-4	SPACER		A/R		
25	1	B14		3740289-5	SPACER		A/R		
26	1	B14		3740289-6	SPACER		A/R		

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	7-17-72	R	ENGR	2-6-73									
G	ENGR	9-20-72	S	ENGRG	3-27-73									
H	ENGR	10-16-72												
J	ENGR	1-22-73												

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PARTS LIST

AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

CODE IDENT NO. 99193

ORIGINAL ISSUE March 9 1972

TITLE: ENGINE ASSY, TURBOJET, EXPENDABLE

PL 3740301 | SECTION | SHEET 4 | PL REV U

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1	REV CODE	REV LTR
27	1	B11		3740404-3	RING, PISTON		2	4	R
28	1	B13		3740394-1	GEAR, SPUR		1	4	G
29	1	C17		3740469-1	IGNITER AND DELAY		1	4	U
30	1	B12		3740396-1	CARRIER, RESILIET MT		1	4	G
31	1	B12		3740254-1	MOUNT, RESILIENT		1		
32	1	B11		3740283-3	TURBINE ROTOR AND SHAFT		1	4	R
33	1	F17		3740340-1	CONNECTOR, SHUNTED		1	4	F
34	1	B14		3740404-4	RING, PISTON		2		
35	1	G14		3740392-1	ROTOR ASSY, COMPRESSOR		ALT	4 4	R G
35	1	G14		3740393-1	ROTOR ASSY COMPRESSOR		1	4	G
36	1	B18		3740403-1	IGNITER, PYROTECHNIC	1	1	4	U
37	1	G16		3740463-1	PWR CONDITIONER		1	4	K
37	1	G16		3740463-2	PWR CONDITIONER		ALT	4	M.
38	1	C16		3740399-1	PLATE, MOUNT, RELIEF VALVE		1	4	S
39	1	C16		771-612-9301	RELIEF, VALVE		1	4	S
40	1	B14		3740271-1	NUT, SLOTED		1		

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72	F	ENGR	7-12-72	M	INC. ADDED	11-30-72	U	ENGRG	3-6-73			
B	ENGRG	5-22-72	G	ENGR	9-20-72	N	ENGR	1-22-73						
C	ENGRG	5-29-72	J	ENGR	10-27-72	P	ENGR	2-6-73						
D	ENGRG	6-26-72	K	ENGR	11-13-72	S	ENGR	2-9-73						

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PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	TITLE ENGINE ASSY, TURBOJET, EXPENDABLE	PL 3740301	PL REV K
	CODE IDENT NO 99193	ORIGINAL ISSUE MARCH 9, 1972	SECTION SHEET 5	

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1							REV CODE	REV LTR
41	1	G15		3740270-2	STATOR ASSY		1							4	A
42	1	G15		3740363-2	NOSE CONE		1							4	K
43	1	G11		3500205-1	TAILPIPE		1								
44	1	G10		3505055-4	STARTER, ENGINE		1							4	G
45	2	C6		3740348-1	HARNESS ASSY		1							4	D
46	1	A17		3740241-1	TUBE, IGNITOR		1								
47	2	C15		3740334-1	TUBE ASSY		1								
48	2	C7		3740384-1	TUBE ASSY		1							4	G
49	1	G11		3740397-2	SPACER		A/R							4	G
50	1	G11		3740397-3	SPACER		A/R							4	G
51	1	G11		3740397-4	SPACER		A/R							4	G
52	1	G11		3740397-5	SPACER		A/R							4	G
53	1	G11		3740397-6	SPACER		A/R							4	G
54														4	G

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72												
D	ENGRG	6-26-72												
G	ENGR	9-20-72												
K	ENGR	11-13-72												

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PARTS LIST

AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

CODE IDENT NO. 99193 | ORIGINAL ISSUE MARCH 9, 1972

TITLE ENGINE ASSY, TURBOJET, EXPENDABLE

PL 3740301 | SECTION | SHEET 6 | PL REV D

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	-1							REV CODE	REV LTR
55	1	G18		3740325-1	BRACKET, MOUNTING, P.C.U.		1							4	D
56	1	F17		3740341-1	BRACKET, MTG, CONNECTOR		1							4	A
57	1	C4		3740338-1	SCREW		5								
58	1	C3		3740338-2	SCREW		1								
59	2	F11		S9098-1-20	WIRE		A/R							4	A
60	1	H15		S9412-016	O-RING		1								
61	1	C19		S8990-013	O-RING		1								
62	1	G19		S9412-011	O-RING		1								
63	1	H15		S8157N249-025	WASHER		2								
64	1	E20		S9412-018	O-RING		1								
65	2	F11		S8928G42E	CABLE		A/R							4	A

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72												
D	ENGRG	6-26-72												

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PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	CODE IDENT NO 99193	ORIGINAL ISSUE MARCH 9, 1972	TITLE ENGINE ASSY, TURBOJET EXPENDABLE	PL 3740301 SECTION SHEET 7	PL REV E

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1							REV CODE	REV LTR
66	1	E15		S8157N242-050	WASHER		1							4	A
66	1	E18		S8157N242-050	WASHER		1							4	A
66	1	E19		S8157N242-050	WASHER		4							4	A
66	1	E20		S8157N242-050	WASHER		2							4	A
67	2	F11		S9350-2	INSULATION SLEEVING		A/R							4	A
67	2	H10		S9350-2	INSULATION SLEEVING		A/R							4	A
68	1	F16		680-514-9401	STRAP ASSY	1	1								
69	1	B5		105-087-9001	COMPOUND	1	A/R								
70	1	A7		219-174-9001	COMPOUND	1	A/R							4	A
71	1	D2		724-515-9010	TERMINAL	1	2							4	D
72	1	F16		680-514-9301	BAND CLAMP	1	1								
72	1	E16		680-514-9301	BAND CLAMP	1	1								
73	1	G14		211-539-9201	COUPLING, VEE	1	1							4	E
74	1	G11		211-539-9202	COUPLING, VEE	1	1								
75	1	A5		219-090-9001	COMPOUND	1	A/R								
76	1	G7		NAS1291C8M	NUT		1							4	A

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72												
D	ENGRG	6-26-72												
E	ENGR	7-5-72												

PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	TITLE ENGINE ASSY, TURBOJET, EXPENDABLE	PL 3740301	PL REV K
	CODE IDENT NO 99193 / ORIGINAL ISSUE March 9, 1972		SECTION / SHEET 8	

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1							REV CODE	REV LTR
77	1	C16		NAS1121-1	SCREW		4								
78	1	B13		NAS1102E3-6	SCREW		8								
79	1	B11		NAS1122-1 H	SCREW		6								
80					—	—								4	K
81	1	D2		AN960C10L	WASHER		2								
82	1	H18		NAS1101E08-5	SCREW		1							4	D
82	1	G17		NAS1101E08-5	SCREW		1							4	D
83	1	H18		AN960C8	WASHER		1								
83	1	G17		AN960C8	WASHER		1								
84	2	C12		AN960 C6L	WASHER		2							4	A
84	1	C16		AN960C6L	WASHER		4								
85	1	E2		AN960C416L	WASHER		1								

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-12-72												
D	ENGRG	6-26-72												
K	ENGR	11-13-72												

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PARTS LIST

AIRESEARCH MANUFACTURING COMPANY OF ARIZONA

CODE IDENT NO. 99193

ORIGINAL ISSUE MARCH 9, 1972

TITLE ENGINE ASSY, TURBOJET, EXPENDABLE

PL 3740301

SECTION

SHEET 9

PL REV U

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1	REV CODE	REV LTR
86	1	D2		MS9489-10	BOLT		2		
87	1	F16		MS9349-02	CLAMP		1	4	A
88	1	C17		MS35769-9	GASKET		1	4	U
89								4	K
89								4	N
89	1	E20		MS16998-27	SCREW		5	4	K
89	1	E15		MS16998-27	SCREW		1		
89	1	C17		MS16998-27	SCREW		4		
89	1	E18		MS16998-27	SCREW		1		
90	1	C15		MS24630-9F	SCREW, TAPPING		2	4	A
91	1	B12		MS21279-06	BOLT		35		
91	1	E20		MS21279-06	BOLT		5	4	N

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE
A	ENGRG	4-17-72
K	ENGR	11-13-72
N	ENGR	12-5-72
U	ENGRG	3-6-73

PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	CODE IDENT NO. 99193	ORIGINAL ISSUE MARCH 9, 1972	TITLE ENGINE ASSY, TURBOJET, EXPENDABLE	PL 3740301 SECTION SHEET 10	PL REV G

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1								REV CODE	REV LTR
92	2	C6		525-580-9002	NUT		6									
92	1	G12		525-580-9002	NUT		6									
92	1	D2		525-580-9002	NUT		2									
93	1	B14		MS20068-99	KEY		1								4	G
94	2	C8		MS51958-60	SCREW		3								4	E
							1								4	D
95	2	C8		338-501-9002	CONNECTOR		2								4	G
96	1	G17		MS16997-30	SCREW		2									
97	1	F17		MS21043-04	NUT		4									
98	1	G7		MS35769-9	GASKET		1								4	A
99	2	C12		MS21043-06	NUT		2								4	A
99	2	C8		MS21043-06	NUT		1								4	G

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGRG	4-17-72												
D	ENGRG	6-26-72												
E	ENGR	7-5-72												
G	ENGR	9-20-72												

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PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	CODE IDENT NO 99193	ORIGINAL ISSUE 3-9-72	TITLE ENGINE ASSY, TURBOJET, EXPENDABLE	PL 3740301 SECTION SHEET 12	PL REV N

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1								REV CODE	REV LTR
110	2	F11		724-532-9001	TERMINAL	1	1								4	A
111	2	H10		672-503-9002	SPLICE	1	4								4	A
112	2	H11		672-503-9003	SPLICE	1	2								4	A
112	2	F11		672-503-9003	SPLICE	1	1								4	A
113	2	F11		672-503-9004	SPLICE	1	1								4	A
114	2	C8		211-501-9111	CLAMP	1	5								4	E
115	1	C20		S8999	BRAID, TEXTILE		A/R								4	E
116	2	G16		219-013-9001	COMPOUND	1	A/R								4	F
117	1	H17		3740369-1	BRACKET, MTG., P.C.U.		1								4	D
118	2	F5		.005THK INCO 600/AMS5540			A/R								4	E
118	2	C6		.005THK INCO 600/AMS5540			A/R								4	K
119	1	F17		S8145-139	TAG		1								4	F
120	2	C7		211-544-9016	CLAMP	1	1								4	G
121	2	C7		337-546-9001	FILTER	1	1								4	G
122	2	B8		AN929-2J	CAP ASSY		2								4	G
123	2	C8		(SEE NOTE 18)	LUBE		AR								4	G
124	1	B10		S9413-007	O-RING		1								4	G
125	1	B10		HFD-30-KK	WIRE THERMOCOUPLE		A/R								4	G
126	1	B10		MITHRA 200	COMPOUND 21		AR								4	G
127	1	E19		S9412-OR	O-RING		1								4	K
128	1	D19		S9093-8205AD	SCREW		2								4	N
129	1	E19		3740443-1	BRACKET		1								4	K
130	1	D19		3740427-1	VALVE ASSY		1								4	K

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGR	4-17-72	G	ENGR	9-20-72									
D	ENGR	5-25-72	K	ENGR	11-13-72									
E	ENGR	7-5-72	N	ENGR	12-5-72									
F	ENGR	7-12-72												

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PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	CODE IDENT NO. 99193	ORIGINAL ISSUE 3-9-72	TITLE ENGINE ASSY, TURBOJET, EXPENDABLE	PL 3740301	SECTION	SHEET 11	PL REV U

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1	REV CODE	REV LTR
100	1	F17		MS51957-14	SCREW		4		
101	1	B11		MS20995C20	LOCKWIRE		A/R		
102	2	C15		MS9025-15	CLAMP		2		
103	2	B8		MS21046C3	NUT		3	4	E
103	2	C15		MS21046C3	NUT		1		
104								4	G
105	1	H15		NAS1351-3C14	SCREW		2	4	N
106	1	F17		M81511/01FB02P1 PER MIL-C-81511/1	CONNECTOR		1	4	A
106	1	D16		M81511/01FB02P1 PER MIL-C-81511/1	CONNECTOR		1	4	U
								4	E
107	2	C8		MS9592-005	BRACKET		3	4	E
108	1	F16		680-508-9001	STRAP, CABLE	1	1	4	A
108	2	F6		680-508-9001	STRAP, CABLE	1	A/R	4	E
108								4	E
109	2	G10		722-506-9001	TAPE	1	A/R	4	A
109	2	F11		722-506-9001	TAPE	1	A/R	4	A
								4	E
101	1	H15		MS20995C20	Lockwire		AR	4	L

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE	REV	AUTHORITY	DATE
A	ENGR	4-17-72	L	INC.ADCEO	11-24-72									
D	ENGR	6-26-72	N	ENG	12-5-72									
E	ENGR	7-5-72	U	ENGRG	3-6-73									
G	EN	2-72												

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PARTS LIST	AIRESEARCH MANUFACTURING COMPANY OF ARIZONA	TITLE ENGINE ASSY TURBOJET, EXPENDABLE	PL3740501	PL REV T
CODE IDENT NO 99193	ORIGINAL ISSUE 11-13-72		SECTION / SHEET NO 13	

FIND NO.	SHT NO.	DWG ZONE	CODE IDENT	PART OR IDENTIFYING NO.	NOMENCLATURE OR DESCRIPTION	USE CODE	DASH NO. AND QUANTITY REQD -1	REV CODE	REV LTR
131	1	C13		3740418-1	CROSS, FLARED TUBE		1	4	K
132								4	T
133								4	T
134	1	F19		MS16998-26	SCREW		2	4	K
135	1	C18		3740462-1	TUBE ASSY		1	4	K
136	1	C17		AN929-4S	CAP		1	4	K
137	1	D16		977012-1	SENSOR, TEMP		1	4	K
138	1	C18		MS9489-07	BOLT		3	4	N
139	1	C18		38157N-169-016	WASHER		3	4	K
140	1	D18		MS24674-7	SCREW		4	4	K
141	1	D18		58157N-7-016	WASHER		4	4	K
142	2	A9		3740453-1	WIRING HARNESS		1	4	K
143	2	C8		3740460-1	TUBE ASSY		1	4	K
144	2	B9		306100-1	COMPUTER ASSY		1	4	K
145	1	D9		3740419-1	BRACKET, VALVE		1	4	P
146								4	T
147	1	D19		3740425-1	FUEL CONTROL		1	4	T
148									

REVISION HISTORY THIS SHEET

REV	AUTHORITY	DATE
K	ENGR	11-13-72
L	ING. ADCEO	11-24-72
N	ENGR	12-5-72
P	ENGR	2-16-73

P 5854-4 (Cont sheet, multi sheet P/L)

AiResearch Manufacturing Company of Arizona
ENGINEERING ORDER

FORM P2552D-2

DRAWING TITLE	ENGINE ASSY, TURBOJET, EXPENDABLE	DWG NO	PL 3740301	CHG LET	V
REVISION		SHEET		OF	
TO BE INCORP IN DRAWING YES / NO	INCORP BY	DATE	INCORP CHK'D BY	DATE	ADV CHG. LET.

MANDATORY	1	DRAWING CHG.	X	VARIATION		VOID AFTER	DATE	DISTRIBUTION	L.A.	PHX.
PRIORITY	2	ADV. DWG. CHG		SUBSTITUTION		VOID AFTER	NO OF PARTS	NORMAL		X
ROUTINE	3	EMERGENCY DWG.		REWORK		S.I.L.	YES / NO	RUSH		
MINOR	4	E.C.P. NO.		MATL. REV. ACT.		SERVICE BULLETIN	YES / NO	TELETYPE		

SHEET	ZONE	ITEM	DESCRIPTION	SPARE PARTS CODE	AUTHORITY	DISPOSITION OF AFFECTED PART
2		1	F/N 2 CHANGED PART NO 3740388-4 MID FRAME WAS 3740388-2		ENG	NOTED
3		2	F/N 16 CHANGED PART NO. 3740292-3 COMBUSTOR & NOZZLE WAS 3740292-2			

NEXT ASSY.	MODEL NO.	M.E.O.	OUTLINE	EFFECTIVITY INSTRUCTIONS
			3740300-1	UNDELIVERED ITEMS
				DELIVERED ITEMS

PARTS LIST CHANGE ONLY—NO EFFECT ON MODEL NO

COORDINATED BY | DATE

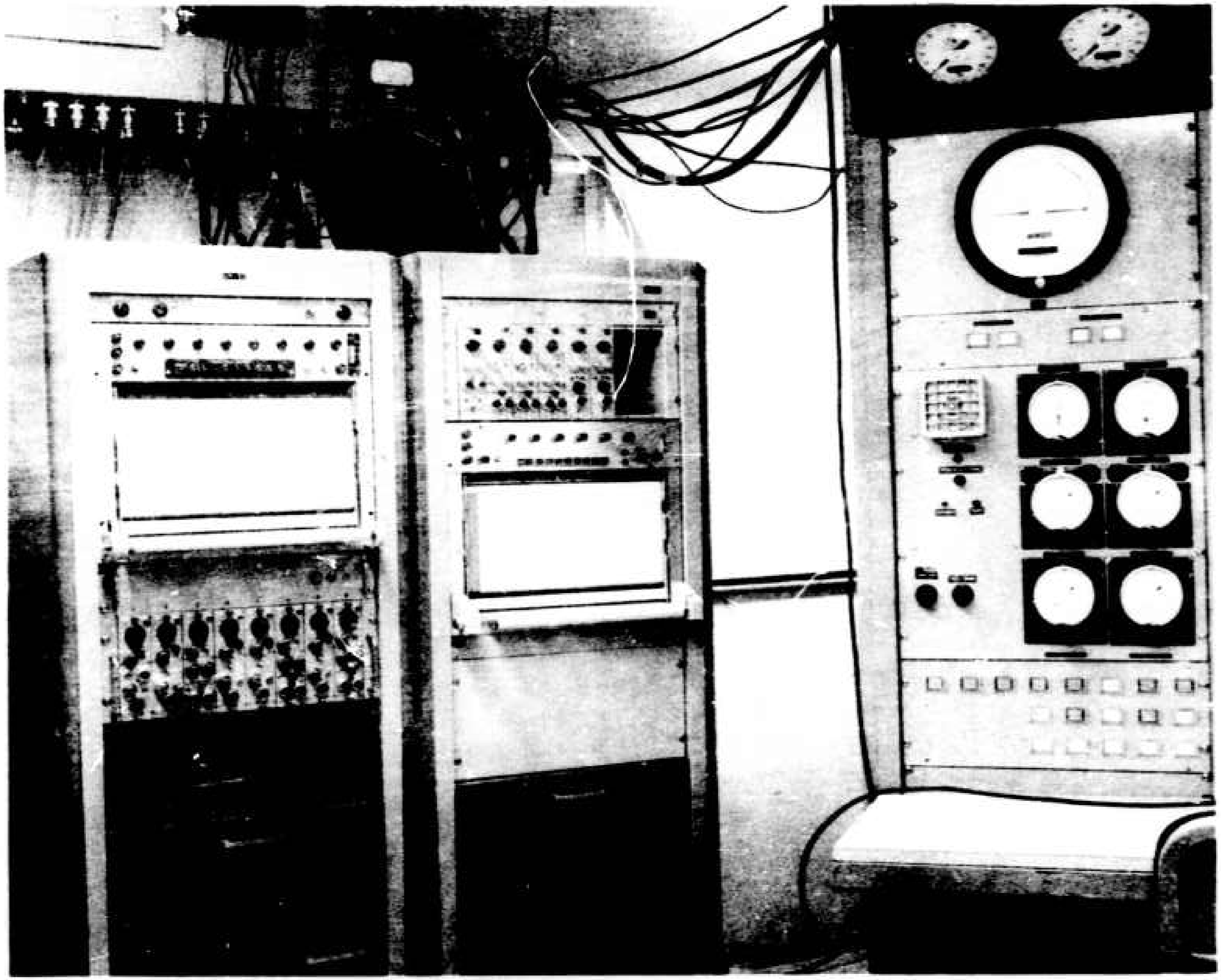
REASON FOR CHANGE: TO BRING ASSEMBLY UP TO LATEST CONFIGURATION

REQUESTED BY	DATE	PREPARED BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
K. JONES	3-28-73	R E K[illegible]	3-28-73	R E K[illegible]	3-28-73	[illegible]	3/28/73

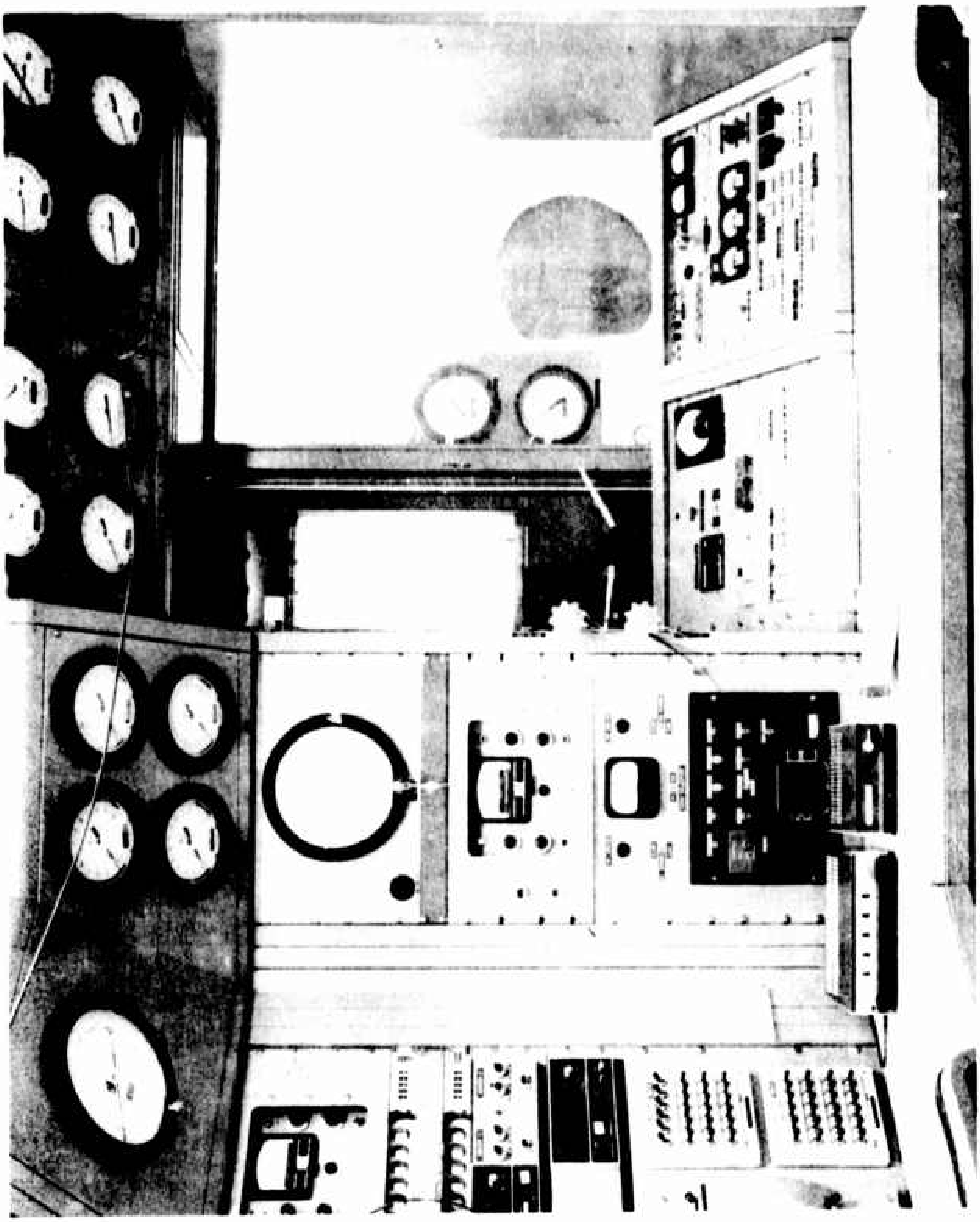
6.2 Facilities and Instrumentation

This section contains facility photographs and instrumentation used during the testing of both IFRT engines. The item and page numbers are as follows:

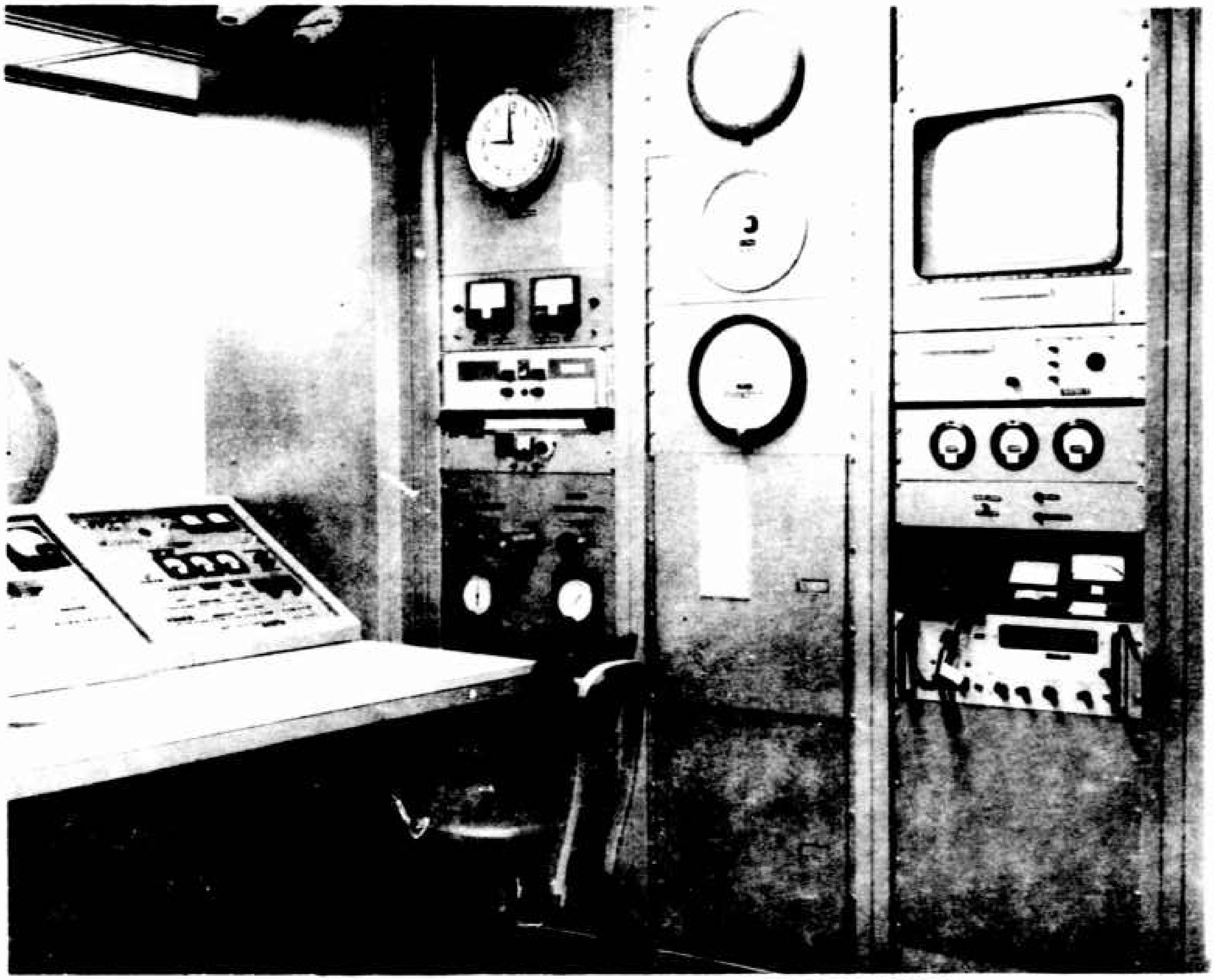
AIR INLET DUCTING AND INTERIOR OF ALTITUDE CHAMBER



PEN RECORDERS AND CHAMBER OPERATION INSTRUMENTATION



ENGINE CONTROLS AND INSTRUMENTATION (NOTE CHAMBER VIEW PORT)



ENGINE CONTROLS AND INSTRUMENTATION (NOTE CLOSED-CIRCUIT TELEVISION MONITOR).

TABLE I. INSTRUMENTATION

Master Number	Parameter	Parameter and Station	Range	Units	Recorded		Visual	Visual Information
					Computer	Traces		
001-004	Inlet air temperature	$T_{t1.0}$	-65 - +200	°F	X	X	X	X
101-106	Turbine discharge temperature	$T_{t\ 7.0}$	0-2000	°F	X	X	X	X
121	Inlet fuel temperature	T_f	0-200	°F	X		X	X
202-205	Bellmouth total pressure	$P_{t1.2}$	-15 to +15	psig	X			
206-209	Bellmouth static pressure	$P_{s1.2}$	-15 to +15	psig	X			
250	Exhaust static pressure	$P_{s8.0}$	-1 to +1	in Hg	X			
269	Turbine discharge total pressure	$P_{t7.0}$	0-50	psig	X		X	
320	Compressor discharge static pressure	$P_{s3.0}$	0-100	psig	X	X		
358	Ram ΔP	$P_{t1.2}-P_{s8.0}$	0-10/0.50	psid/in Hg	X	X	X	X
363	Ambient altitude pressure	P_{AMB}	0-30	in. Hg A	X			X
377	Inlet fuel pressure	P_f	0-50	psia	X	X		X
(6) 385	Bearing thrust cavity pressure	P_{cav}	0-100	psia	X	X		
386	Seal ΔP	ΔP_{SEAL}	0-100	psia				X
401	Engine speed	N	0-50,000	rpm	X	X	X	X
403	Engine thrust	F_{MEAS}	0-800	lbs	X		X	
405	Fuel flow	W_f	0.2-3.0/0-2000	gpm/pph	X	X	X	X
409	Engine vibration	C_{VIB}	0-5	mils		X	X	X
455	Output current	A	0-200	amps	X	X	X	X
457	Output voltage	V_L	0-50	vdc	X	X	X	X

TEST INSTRUMENTATION AND EQUIPMENT

Instrument or Equipment	Manufacturer	Model, Type or Size	Range	Accuracy	Maximum Calibration Period (Days)
Thermocouple Thermometers	Doric Scientific Corp.	DS-100-T3	-	±0.05%	90
	Honeywell, Minneapolis, Minn.	Electronik	0 - 2000°F	±5°F	90
Manometers	The Meriam Instrument Co, Cleveland, Ohio	Various	0 - 100 in.	0.1%	90
Pressure Gauges	Heise Newtown, Conn.	Various			
	Ashcroft Gauges, Manning, Maxwell & Moore, Inc, Stratford, Conn.	Duragauge	0 - 60 psig 0 - 300 psig 0 - 1000 psig	±0.25 psi ±0.25 psi ±0.25%	90
	American Chain & Cable, Helicoid Gage Div, Bridgeport, Conn.	Various			
Flowmeters	Cox Instrument Div, Lynch Corp, Detroit, Mich.	Series 12	4.5 - 26 PPH 26 - 140 PPH 130 - 800 PPH 750 - 5000 PPH	±1.6 PPH ±2.7 PPH ±5.0 PPH ±15.0 PPH	365
	Fischer & Porter, Warminster, Pa.	-	40 - 180 PPH 110 - 600 PPH	±0.8 PPH ±7.6 PPH	365
	Flow Technology Tempe, Ariz.	FT-8M3-LB FT-20-LB	0.3 - 3.0 gpm 0.2 - 2.0 gpm	±0.7% ±0.7%	365 365
Digital Counters	Anadex Instruments Inc, Van Nuys, Calif.	CF-201R	-	±1 count	90
		CF-601R	-	±1 count	90
Vibration Sensing Systems	Consolidated Electrodynamics Corp. (Transducer Div.), Monrovia, Calif.	Type 1-117 (Amplifier)	0 - 5 mils	±3%	120
Differential Pressure Gauge	Wallace & Tiernan, Inc, Belleville, N.J.	FA145			
Pen Recorders	Hewlett-Packard Corp, Palo Alto, Calif.	1069-03A 7700 Series	As specified for parameter measured	±3% of full scale	1
	Sanborn Waltham, Mass.	850	As specified for parameter measured	±3% of full scale	1

TEST INSTRUMENTATION AND EQUIPMENT

Instrument or Equipment	Manufacturer	Model, Type or Size	Range	Accuracy	Maximum Calibration Period (Days)
Force Measurement	Doric Scientific Corp.	DS-100-T2	0 - 5000 lb	$\pm$5 lb	90
Thermocouples	AiResearch	Various	-100 to 500°F 500 to 1400°F	$\pm$2°F $\pm$3/8%	90
Airflow Sections	AiResearch	A.S.ME. low beta series	-	$\pm$0.05 lb/sec	365
Load Cells	Interface	Model 1111-5K	0 - 5000 lb	$\pm$2.9 lb	1
Transducers	Statham Viatran	Various Various	0 - 600 psig 0 - 30 psig	$\pm$0.25% $\pm$0.25%	As used As used
Field Power Supply	Lambda Electronic Corp, Melville, N.Y.	LK351-FM	0 - 36 vdc 0 - 15 amps	-	-
Ammeter	Weston	Model 1	0 - 300 amps	$\pm$1.0%	90
Integrating Digital Voltmeter	Hewlitt-Packard	Model 2401C	0 - 30 vdc	$\pm$0.5%	90
Load Bank	AiResearch	SK-50A-D602	0 - 280 amps at 30 vdc	-	-
Timer	Standard	-	0 - 1000 sec	$\pm$0.01%	180

IDENTIFICATION OF INSTRUMENTATION USED DURING TESTS.

Parameter	Station	Location in Test Setup	Type of Instrument	Serial No.	Expiration Date
Inlet air temperature	$T_{t1.0}$	Bellmouth Console Control room	Thermocouples Thermocouple thermometer Recorder	-- LTR401 S/N 62	-- 5-1-73 9-23-73
Engine exhaust temperature	$T_{t7.0}$	Engine Console Control room	Thermocouples Thermocouple thermometer Recorder	-- LTR342 S/N 88	-- 5-1-73 4-19-73
Inlet fuel temperature	T_f	Fuel system Console	Thermocouple Thermocouple thermometer	-- LTR401	-- 5-1-73
Bellmouth total	$P_{t1.2}$	Bellmouth Console	Pressure rake Pressure gauge	-- LG3330	-- 5-1-73
Bellmouth static	$P_{s1.2}$	Bellmouth	Pressure rake	--	--
Turbine discharge total pressure	$P_{t7.0}$	Engine Console	Pressure rake Pressure gauge	-- LG3332	-- 5-1-73
Compressor discharge static pressure	$P_{s3.0}$	Engine Console Control room	Pressure tap Pressure gauge Recorder	-- LG3333 S/N 83	-- 5-1-73 --
Ram ΔP	$P_{t1.2} - P_{s8.0}$	Bellmouth & engine Console Control room	Pressure rake and taps Manometer Recorder	-- LM533 S/N 88	-- 5-1-73 4-19-73
Ambient pressure	P_{BAR}	Altitude chamber Console	Pressure tap Manometer	-- LM533	-- 5-1-73
Exhaust static pressure	$P_{s8.0}$	Engine Console	Pressure tap Pressure gauge	-- LG3366	-- 7-9-73
Engine speed	N	Engine Console Control room	Frequency pickup Digital counter Recorder	-- EF 232 S/N's 62 and 88	-- 5-1-73 --
Engine thrust	F_{MEAS}	Thrust stand Console	Load cell Digital counter	-- LTR347	-- 5-1-73
Fuel flow	W_f	Fuel system Console Altitude chamber Control room	Turbine meter Digital counter Rotometers Recorder	FM84 EP34 LR263-266 S/N 88	-- 5-1-73 5-7-73 --
Engine vibration	C_{VIB}	Engine Console Control room Control room	Accelerometer Meter Recorder Spectrum analyzer	-- VIB98 S/N 88 --	-- 7-29-73 -- --
Output current	A	Load bank Console Control room	Shunt Meter Recorder	-- LA231 S/N 62	-- 5-1-73 --
Output voltage	V_L	Load bank Console Control room	Voltage taps Digital voltmeter Recorder	-- EC207 S/N 62	-- 5-1-73 --
Run time	--	Console	Timer	LTC49	7-31-73
Inlet fuel pressure	P_{f-}	Altitude chamber Console Control room	Pressure tap Pressure gauge Recorder	-- LG3334 S/N 88	-- 5-1-73 --

6.3 Quality Control Reinspection Records

This section contains the Teardown Deficiency Write-up and the Quality Control Reinspection Record cards for each engine. The item and page numbers are as follows:

P-6410C

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

CASE NO. 1-5

REPORT NO. 7-15

~~OSWO 110~~

TEAR DOWN DEFICIENCY WRITE-UP

PROGRAM: HARPOON	CODE 16-18: - - -	19-23 MONTH / DATE DAY / YR.: 04 09 3	CUSTOMER 24-26 (TRLR 58-60): - - -	IFRT TEST
LOCATION 27-30: 4722	OUTLINE OR ASSY NO. 31-41 (TRLR 61-71): 3740300-1	MODEL NO. OR NAME 42-53: XJ-401-GA-400	OUTLINE SER NO. 54-62 (TRLR 72-80): IFRT #1	
HOURS 63-66: 29.29	STARTS 63-66: 5	TASK: 13 OVERHAUL, 14 REPAIR, 18 MODIFY, 19 PROD. REJ., 00 OTHER	CODE 67-68: 00; ACT. 71: -; DSP. 72: -; SYMPTOM 73-75: - - -	
PROD LINE 76-78: - - -	ADC 80	SIGNATURES: [signature]	POST COLD SOAK - ALTITUDE START TEST	

PART NUMBER 7-16	PART NAME 17-24	SERIAL NO. 25-33	CONDITION	FLR TYPE 43	PRT DISP 44	FLR CNF 45	NAME CODE 46-48	COND. CODE 49-50
3740393-1	COMPRESSOR ROTOR	AC-17	3RD STAGE					
EPON ERRODED 360° - SLIGHT 1ST STAGE KISS								
3740274-2	COMPRESSOR STATOR	72X-150	SLIGHT					
RUBB ON 1ST STAGE APPROX 30° ARC. - EPON EROSION ON 4th STAGE EPON								
3740253-3	TURBINE WHEEL	S/N 958	RUBBED					
ON BACK THRUST FLANGE & OD SEAL ~~[illegible]~~. AFT OF THE CARBON SEALS.								
3740290-1	BEARING	3-106	~~SEPARATOR~~					
~~[illegible]~~ - BEARING TURNS BUT NOT SMOOTHLY, BALLS WEARING - SEPARATOR WEARING - METAL DEPOSITION ON INNER RACE								
REAR BRG CARRIER	3740409-1	NONE	ID					
Rubbed by the Turbine wheel								

OVERHAUL ENGINEERING

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] C/L [illegible]
PART NAME Rotor Assembly Compressor, [illegible]

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N AE-17

NO.	Dimension and Location		B P max./min.	Before	After	Remark
1	D/A 8.481		8.481 / BSC	8.486	8.486	assy clearance
2	D/A 8.381		8.381 / BSC	8.375	8.4 [illegible]	under [illegible] min
3	D/A 8.277		8.277 / BSC	8.278	8.279	
4	D/A 8.215		8.215 / BSC	8.217	8.217	
5	D/A 8.128		8.128 / BSC	8.1275	8.1275	
6	D/A 8.085		8.085 / BSC	8.085	8.085	
7	D/A 8.059		8.055 / BSC	8.061	8.060	
8	D/A 8.025		8.025 / BSC	8.027	8.0257	
9	D/A 5.700		5.700 / BSC	5.695	5.697	
10	D/A 5.862		5.862 / BSC	5.862	5.862	

Inspection Before [signature] Date 3-3-73 Quality Control ___ Date ___
After [signature] Date 4-9-73 Engineering [signature] Date 4-9-73

SHEET 2 OF 4

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] C/L [illegible]
PART NAME Rotor Assembly Compressor, Balanced

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N AE-17

NO.	Dimension and Location		B P max./min.	Before	After	Remark
1	DIA 6.213		6.213 / BSC	6.215	6.22	assembly clearance normal
2	DIA 6.332		6.332 / BSC	6.338	6.340	
3	DIA 6.561		6.561 / BSC	6.542	[illegible]	assembly clearance normal.
4	DIA 6.637		6.637 / BSC	6.645	NA	
5	DIA LABYRINTH SEAL		6.444 / 6.442	[illegible]	6.446 / 6.446	
6	DIA BORE - A -		1.5745 / 1.5743	1.5745 / 1.5743	1.5745 / 1.5743	
7	⊥ A .0002 TWO PLACES		.0002	.0002	.0002	
8	DIA REF.		2.100 / 2.099	2.0995	2.098 / 2.098	
9						
10						

Inspection Before [signature] Date ___ Quality Control ___ Date ___
After [signature] Date 4/9/73 Engineering [signature] Date 4-9-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] C/L [illegible]
PART NAME [illegible]

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N AE-17

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	RUNOUTS - TO 1.5745 [illegible] DIA					
2	1ST BLADE		.002	[illegible]	.0035	
3	2ND BLADE		.002	[illegible]	.0025	
4	3RD BLADE		.002	[illegible]	[illegible]	
5	4TH BLADE		.002	.0020	[illegible]	
6	LABYRINTH		.002	.01	.004	
7	FRONT 2.53 / 2.50 DIA RUNOUT		.002	.004	.006	[illegible]
8	1ST ABRADABLE		.002	[illegible]	.0135	
9	2ND ABRADABLE		.002	.003	.0055	
10	3RD ABRADABLE		.002	.002	.003	

Inspection Before [signature] Date [illegible] Quality Control ___ Date ___
After [signature] Date [illegible] Engineering [signature] Date [illegible]

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] C/L ___
PART NAME [illegible]

Next Assembly ___ C/L ___ Final Assembly ___ S/N AE-17

NO.	Dimension and Location		BP max/min	Before	After	Remark
1						
2						
3	BALANCE PLANE N [illegible]		[illegible]			
4	BALANCE PLANE M [illegible]		[illegible]			
5						
6						
7						
8						
9						
10						

Inspection Before ___ Date ___ Quality Control ___ Date ___
After ___ Date ___ Engineering ___ Date ___

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740283 C/L R
PART NAME TURBINE ROTOR & SHAFT

Next Assembly 3740301 C/L ___ Final Assembly ___ S/N 958

NO.	Dimension and Location		BP	Before	After	Remark
1	LABYRINTH DIA.		6.001 / 5.999	6.0005	5.994 / 5.992	
2	BLADE TIP DIA.		9.548 / 9.547	9.547	9.552 / 9.549	
3	SHAFT DIA 3 PLACES		1.5750 / 1.5745	1.5750	1.5751 / 1.5749	
4	1.5749 TO B-C 3 PLACES		.0004	.0002	.0001 / .0003	
5	9.548 DIA TO B-C		.001	.0007	.0005	
6	⊥ -F- TO B-C		.0003	.0002	.0003	
7	PISTON SEAL AREA DIA.		1.967 / 1.966	1.9665	1.967	
8	⊥ -A- TO B-C		.002	.0005	.0012	
9	TO A-B OF 1.967-1.966		.001	.0007	.0008	
10	LENGTH		15.425 / 15.4	15.425	15.424	

Inspection Before [redacted] Date [redacted] Quality Control [signature] Date 4-4-73
After [signature] Date 4/4/73 Engineering [signature] Date 4-4-73

958

2 of 2

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740283 C/L R
PART NAME TURBINE ROTOR SHAFT

Next Assembly ___ C/L ___ Final Assembly ___ S/N 958

NO.	Dimension and Location		BP	Before	After	Remark
1	DIA HOLES	E	.186 / .191	.188 / .186	.188 / .190	
2	DIA HOLES	E	.129 / .124	.128 / .125	.128 / .124	
3	BALANCE PLANE P (OZ-IN)	BAL	.010	.0038		BAL
4	BALANCE PLANE Q (OZ-IN)		.010	.0051		
5						
6						
7						
8						
9						
10						

Inspection Before [signature] Date 3-30-73 Quality Control E.T. [signature] Date 4-3-73
After [signature] Date 4/3/73 Engineering W.E. Williams Date 4-3-73

QUALITY CONTROL [illegible]

3740290 -L C/L C
BEARING
S/N 3-106

NO.	Dimension and Location	B P max/min	Before	After	Remark
1	CONTACT ANGLE	24° / 20°	22'		
2	SEPARATOR PILOT CLEAR	.020 / .014	.017		
3	BALL POCKET CLEARANCE	.025 / .020	.022		
4	BALL SIZE VARIATION	.000025	.000010		
5	AXIAL CLEAR. UNDER AN 11 LB. GAGE LOAD	.030 MAX	.023		
6					
7					
8					
9					
10					

Inspection Before J. DOUDS Date 3/27/73 Quality Control E. L. Dinkel Date 04-4-73
After ______ Date ______ Engineering Don T. Christ Date 5-8-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3587?3-2 C/L A
PART NAME BEARING SET

Next Assembly 3740303-2 C/L A Final Assembly 3740301 S/N 2208

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	DIAMETRAL CLC.		.0012 / .0008	.0011	.0011	
2	End clearance		.0016 / .0007	.0013	.0013	
3	ROLLER DIA		.2785 / .2775	.2755	.2755	
4	INNER RACE I.D.		1.5730 / 1.5745	1.57465	1.5747.0	
5	AGF OF INNER RACE		.0007	.0005	.0002	
6	DIAMETER INNER RACE		1.850 / 1.846	1.8455	1.8488	
7	DIAMETER OUTER RACE		2.421 / 2.397	2.401	2.401	
8	FHÜ OF 2.421-2.397		.0003	.0001	.0001	
9	// H OF 2.421-2.397		.0001	.00005	.0001	
10						KMJ

Inspection Before Kollar Date 4-13-73 Quality Control ______ Date ______
After J. DOUDS Date 04-9-73 Engineering Don T. Christ Date 5-8-73

[illegible] Company of Arizona

QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740270-2 **C/L** E SH. 1
PART NAME STATOR ASSEMBLY, SET, MATCHED

Next Assembly ________ **C/L** ____ **Final Assembly** ________ **S/N** [redacted]

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	DIA.	D6	8.358 / 8.[illegible]	8.360	8.36[illegible] / 8.359	[redacted]
2	DIA.	E9	8.780 / 8.779	8.780	8.781 / 8.779	
3	DIA.	E8	5.757	5.751	5.7515	
4	DIA.	E8	5.918	5.9135	5.914	
5	DIA.	D7	6.277	6.271	6.2705	
6	DIA.	D7	6.385	6.3845	6.3[illegible]	
7	DIA.	D7	6.61[illegible]	6.6135	6.6125	
8	DIA.	D7	6.69[illegible]	6.6905	6.693	
9	DIA.	C11	8.526	8.523	8.525	
10	DIA.	C11	8.42[illegible]	8.4245	8.426	

Inspection Before ________ **Date** ____ **Quality Control** ________ **Date** ____
After ________ **Date** ____ **Engineering** ________ **Date** ____

AiResearch Manufacturing Company of Arizona

QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740270 **C/L** ____ SH2
PART NAME ________

Next Assembly ________ **C/L** ____ **Final Assembly** ________ **S/N** ________

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	DIA.	B10	8.324	8.3255	8.3255	
2	DIA.	B10	8.262	8.2625	8.262	
3	DIA.	B10	8.182	8.181	8.176	
4	DIA.	B10	8.128	8.131	8.127	
5	DIA.	B10	8.099	8.0985	8.092	
6	DIA.	B10	8.064	8.0655	8.052	
7						
8						
9						
10						[illegible]

Inspection Before [illegible] **Date** 3-20-73 **Quality Control** ________ **Date** ____
After [illegible] **Date** 4-9-73 **Engineering** W. C. Williams **Date** 3-30-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] 79-L C/L [illegible]
PART NAME [illegible]

Next Assembly [illegible] C/L [illegible] Final Assembly [illegible] S/N 228128

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	DIAMETER	C-14	6.331 / 6.328	6.330	[illegible]	
2	LENGTH	C-13	.477 / .473	.477	.477	
3	-J- // TO -F-	C-13	.001	.001	[illegible]	
4	-D- // TO -J-	C-12	.001	.008	.008	
5	DIAMETER	D-12	4.624 / 4.622	.4623	4.623	
6	⊥ JK OF 4.623 DIA	E-11	.001	.0008	.001	
7	DIAMETER -G-	E-14	[illegible]	8.358	[illegible]	
8	DIAMETER	E-11	[illegible]	11.652	11.686 / 11.656	
9	[illegible]	E-11	[illegible]	.0015	.0018	
10	DIAMETER [illegible]	E-5	[illegible]	6.466	[illegible]	

Inspection Before [illegible] Date [illegible] Quality Control [illegible] Date [illegible]
After [illegible] Date [illegible] Engineering [illegible] Date [illegible]

2 of 2

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible] 79-L C/L [illegible]
PART NAME [illegible]

Next Assembly [illegible] C/L [illegible] Final Assembly [illegible] S/N [illegible]

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	⊥ OF 6.466 DIA	E-5	.001	.0009	.001	
2	DIAMETER 5 PLACES	[illegible]	.5012 / [illegible]	[illegible]	[illegible]	
3						
4						
5						
6	FUEL FLOW DISTRIBUTION [illegible]		5% MAX	4.6	3.9	
7						
8						
9						
10						

Inspection Before [illegible] Date [illegible] Quality Control [illegible] Date 3/29/77
After [illegible] Date [illegible] Engineering W. C. [illegible] Date 3/29/77

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL REINSPECTION RECORD

PART NUMBER [illegible] C/L
PART NAME Gearshaft, Spur

Next Assembly [illegible] C/L Final Assembly S/N # 3

NO.	Dimension and Location		B.P.	Before	After	Remark
1	DIA -A-		[illegible]	[illegible]	[illegible]	
2	⊥ -A- OF -B-		[illegible]	[illegible]	[illegible]	
3	∥ -B-		.0003	[illegible]	[illegible]	
4	LENGTH		[illegible] .735	[illegible]	[illegible] .733	
5						
6						
7						
8						
9						
10						XHA

Inspection Before [illegible] Date [illegible] Quality Control Date
After [illegible] Date [illegible] Engineering [illegible] Date 4-4-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL REINSPECTION RECORD

PART NUMBER 3740292-3 C/L G
PART NAME Combustor and [illegible]
3740292 [illegible]

Next Assembly [illegible] C/L Final Assembly S/N 1479

NO.	Dimension and Location		B.P.	Before	After	Remark
1	∥ OF A TO F	G-4	[illegible]	.010	.009	
2	DIAMETER	F-4	[illegible] 10.655	[illegible]	10.648	
3	⌀ FG OF 10.656-10.655	F-4	.002	.012	.011	
4	SEAL DIAMETER	F-8	6.017 6.015	6.015	[illegible]	REF 3740294
5	⌀ AB OF SEAL DIAMETER	F-8	.002	.005	[illegible]	REF 3740294
6	DIAMETER	E-7	[illegible]	9.797 9.804	[illegible]	REF 3740294
7	DIAMETER	E-7	[illegible] 9.599	9.597 [illegible]	[illegible]	REF 3740294 [illegible]
8	⌀ OF 9.601/9.599 DIA. TO AB	E-7	.003	.006	.010	REF 3740294
9						
10						XHA

Inspection Before [illegible] Date 3-30-73 Quality Control [illegible] Date 4-4-73
After [illegible] Date 4/4/73 Engineering [illegible] Date 4-4-73

Note: [illegible]

P-8410C

AiResearch Manufacturing Company of Arizona
PHOENIX, ARIZONA

CASE NO. 1-5

REPORT NO. 7-15 3209-410019-73-0100
~~C.S.W.O. 1-8~~

TEAR DOWN DEFICIENCY WRITE-UP

	PROGRAM	CODE 16-18	19-23 MONTH	DATE DAY	YR	CUSTOMER 24-26 (TRLR 58-60)
6 A	Harpoon	- - -	0 4	0 4	3	- - - IFRT

	LOCATION 27-30	OUTLINE OR ASSY. NO. 31-41 (TRLR 61-71)	MODEL NO. OR NAME 42-53	OUTLINE SER NO. 54-62 (TRLR 72-80)
6 A	4 7 2 2	3740300-1	XJ-401-GA-400	IFRT #2

	~~HOURS 63-66~~ MIN/SEC	~~STARTS~~ 63-66	TASK	CODE 67-68	ACT. 71	DSP. 72	SYMPTOM 73-75
6 A	33:29	5	13 OVERHAUL 19 PROD. REJ. 14 REPAIR 00 OTHER 16 MODIFY	0 0	-	-	

	PROD LINE 76-78	ADC 80	SIGNATURES	
6 A	- - .	-	[signature]	Post Handling & Hot Soak

TRLR 6	PART NUMBER 7-16	PART NAME 17-24	SERIAL NO. 25-33	CONDITION	FLR TYPE 43	PRT DISP 44	FLR CNF 45	NAME CODE 46-48	COND. CODE 49-50
	3740393-1	Compressor Rotor	AC 23						
	3rd Stage E	Pon Erroded	360° —						
	No other Discrepancy Noted								

OVERHAUL ENGINEERING

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740283 C/L R
PART NAME TURBINE ROTOR & SHAFT

Next Assembly 3740301 C/L ___ Final Assembly ___ S/N [illegible]

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	LABYRINTH DIA.		6.001 / 5.999	6.000	6.001 / 5.999	
2	BLADE TIP DIA.		9.540 / 9.547	9.549	9.554 / 9.551	
3	SHAFT DIA 8 PLACES		1.5750 / 1.5748	1.5750 / 1.5749	1.5751 / 1.5748	
4	⌀1.5749 TO B-C 8 PLACES		.0004	.0001	.0003 / .0001	
5	⌀ 9.548 DIA TO B-C		.001	.0008	.0007	
6	⊥ -F- TO B-C		.0008	.0000	.0002	
7	PISTON SEAL AREA DIA.		1.967 / 1.966	1.966	1.965 / 1.966	
8	⊥ -A- TO B-C		.0002	.0009	.0008	
9	⌀ TO A-B OF 1.967-1.966		.001	.0006	.0006	
10	LENGTH		15.45 / 15.41	15.439	15.438	

Inspection Before [illegible] Date 2/12/73 Quality Control [illegible] Date 4-1-73
After [illegible] Date [illegible] Engineering ___ Date ___

2 - 2

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740283 C/L P
PART NAME TURBINE ROTOR SHAFT

Next Assembly ___ C/L ___ Final Assembly ___ S/N ___

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	DIA HOLES	E-8	.186 / .191	.1864	.1861	
2	DIA HOLES	E-7	.129 / .124	.1245 / .125	.1243 / .1250	
3	BALANCE PLANE P (OZ-IN)		.010	.008		
4	BALANCE PLANE Q (OZ-IN)		.010	.009		
5						
6						
7						
8						
9						
10						

Inspection Before ___ Date ___ Quality Control [illegible] Date 4-1-73
After ___ Date ___ Engineering W. P. Wilkens Date 4-1-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740393-L C/L
PART NAME ROTOR ASSEMBLY COMPRESSOR BALANCED

Next Assembly 3740301 C/L ___ Final Assembly ___ S/N AC-23

NO.	Dimension and Location		B P MAX/MIN	Before	After	Remark
1	DIA 8.481		8.48[illegible] / BSC	215 8.484	8.4895	
2	DIA 8.361		[illegible]	215 8.3855	215 8.3855	
3	DIA 8.277		8.277 / BSC	215 8.2755	215 8.275	
4	DIA 8.215		[illegible] / BSC	215 8.2135	8.2145	
5	DIA 8.138		8.138 / BSC	215 8.1385	8.140	
6	DIA 8.085		8.085 / BSC	8.085	215 8.087	
7	DIA 8.059		8.059 / BSC	215 8.059	215 8.059	
8	DIA 8.025		8.025 / BSC	215 8.0245	8.025	
9	DIA 5.700		5.70[illegible] / BSC	5.701	5.701	
10	DIA 5.862		5.8[illegible] / BSC	5.862	215 5.863	

Inspection Before ______ Date ______ Quality Control [signature] Date 3-7-73
After ______ Date ______ Engineering [signature] Date 3-7-73

7H9 3-27

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740393-1 C/L NC
PART NAME ROTOR ASSEMBLY COMPRESSOR BALANCED

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N AC 23

NO.	Dimension and Location		B P MAX/MIN	Before	After	Remark
1	DIA 6.219		6.2[illegible] / BSC	215 6.216	6.213	
2	DIA 6.332		6.33[illegible] / BSC	215 6.332	215 6.332	
3	DIA 6.561		6.561 / BSC	215 6.559	215 6.553	
4	DIA 6.637		6.637 / BSC	215 6.6355	N/A fit in OK	
5	DIA LABYRINTH SEAL		6.444 / 6.442	[illegible]	check metal with mid frame	
6	DIA BORE - A -		1.574[illegible] / 1.574[illegible]	1.5740 / 1.574[illegible]	1.5745 / 1.574[illegible] OK	2
7	⊥ A .0002 TWO PLACES		.0002	.0002	.0002	
8	DIA REF		2.120 / [illegible]	2.0995 / 2.1000	2.0995 / 2.1000	
9						
10						3-29

Inspection Before S. J. [signature] Date 3-1-73 Quality Control [signature] Date 3/7/73
After [signature] Date 4-7-73 Engineering [signature] Date 3-7-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740393 C/L NC
PART NAME Rotor Assembly Compressor Balanced

Next Assembly 3740381 C/L ___ Final Assembly ___ S/N AC-23

NO.	Dimension and Location		BP max./min.	Before	After	Remark
1	Runouts - To 1.5745 / 1.5733 Dia					
2	1st Blade		.002	.0005		
3	2nd Blade		.002	.002		
4	3rd Blade		.002	000		
5	4th Blade		.002		007	
6	Labyrinth		.002		007	
7	Front 2.53 / 2.520 Dia Runout		.002		007	REF. 3740370
8	1st Abradable		.002	.001		
9	2nd Abradable		.002	.002		
10	3rd Abradable		.002	.001		

Inspection Before ____________ Date ______ Quality Control [illegible] Date 3-7-73
After ____________ Date ______ Engineering [illegible] Date 3-7-73

KHJ 7-27

4 of 4

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740393 C/L NC
PART NAME Rotor Assembly Compressor Balanced

Next Assembly ____________ C/L ___ Final Assembly ___ S/N AC-23

NO.	Dimension and Location		BP max./min.	Before	After	Remark
1						
2						
3	Balance Plane N (units)		8	Rebalanced 3-10-73		
4	Balance Plane M (units)		8			
5						
6						
7						
8						
9						
10						

Inspection Before ____________ Date ______ Quality Control [illegible] Date 3-7-73
After ____________ Date ______ Engineering [illegible] Date 3-7-73

KHJ 7-27

AiResearch Manufacturing Company of Arizona

QUALITY CONTROL REINSPECTION RECORD

PART NUMBER 3740270-2 C/L N/C

PART NAME STATOR ASSEMBLY, SET, MATCHED

Next Assembly ______ C/L ____ Final Assembly ______ S/N [redacted]

NO.	Dimension and Location		BP max./min.	Before	After	Remark
1	DIA.	D6	8.338 / 8.[illegible]	8.360	8.360 / 8.337	[redacted]
2	DIA.	E9	8.780 / 8.779	8.779	8.780 / 8.777	
3	DIA.	E8	5.753	5.751	5.749	
4	DIA.	E8	5.915	5.912	5.911	
5	DIA.	D7	6.271	6.2695	6.2685	
6	DIA.	D7	6.385	6.382	6.382	
7	DIA.	D7	6.614	6.6115	6.6115	fit with mating part OK.
8	DIA.	D7	6.690	6.6875	6.688	
9	DIA.	C11	8.526	8.517 / ~~8.520~~	8.518	AB .005 / 15.012 HR 47210
10	DIA.	C11	8.426	8.420 / ~~8.423~~	8.420	AB .005 / 13.011 HR 47210

Inspection Before ______ Date ______ Quality Control [signature] Date 5-27-73

After ______ Date ______ Engineering [signature] Date 2-13-73

AiResearch Manufacturing Company of Arizona

QUALITY CONTROL REINSPECTION RECORD

PART NUMBER 3740270 C/L ____

PART NAME ______

Next Assembly ______ C/L ____ Final Assembly ______ S/N [redacted]

NO.	Dimension and Location		BP max./min.	Before	After	Remark
1	DIA.	B10	8.324	8.322	8.3205	
2	DIA.	B10	8.262	8.259	8.2575	
3	DIA.	B10	8.181	8.1825	8.179	
4	DIA.	B10	8.128	8.134	8.1305	AB .005 / 15.006 ITR 47210
5	DIA.	B10	8.098	8.0955 / ~~8.093~~	8.0945	AB .005 / 15.008 ITR 47210
6	DIA.	B10	8.064	8.0635 / ~~8.0675~~	8.0625	AB .005 / 14.0065 ITR 47210
7						
8						
9						
10						2-8

Inspection Before [signature] Date 12-8-72 Quality Control [signature] Date 3/27/73

After [signature] Date 4-6-73 Engineering [signature] Date 2/8/73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740479 C/L
PART NAME [illegible]
REF [illegible]

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N 22X113

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	DIAMETER	C-14	6.331 / 6.328	6.3780 / 6.3777	6.3782 / 6.3785	
2	LENGTH	C-13	.477 / .473	.477	.477	
3	-J- // TO -F-	C-13	.001	.0009	.001	
4	-D- // TO -J-	C-12	.001	.001	.001	
5	DIAMETER	D-12	4.624 / 4.622	4.624	4.624	
6	⊥ JK of 4.623 DIA	E-11	.001	.001	[illegible]	
7	DIAMETER -G-	E-14	8.3[illegible] / [illegible]	8.3380 / 8.3375	8.3377 / 8.357	
8	DIAMETER	E-11	10.658 / 10.6[illegible]	10.657 / 10.656	10.657 / 10.656	
9	⊥ B TO -F-G-	E-11	.002	.0018	.0079	[illegible] 3-29
10	DIAMETER [illegible]	E-5	6.46[illegible]	6.468 / 6.467	[illegible]	Fit correct with mating [illegible]

Inspection Before [illegible] Date [illegible]
After [illegible] Date [illegible]
Quality Control [illegible] Date 3-29-73
Engineering [illegible] Date 3-29-73

2 OF 2

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740479 C/L [illegible]
PART NAME [illegible]

Next Assembly [illegible] C/L ___ Final Assembly ___ S/N 22X113

NO.	Dimension and Location		BP max/min	Before	After	Remark
1	⊥ OF 6.466 DIA	E-5	.001	.0009	.0009	
2	DIAMETER 5 PLACES	A-15	.5012 / .5005	.5071 / .5707	.5070 / .5707	
3						
4						
5						
6	FUEL FLOW DISTRIBUTION ON MANIFOLD T[illegible]		5% / MAX	4.4%		
7						
8						
9						
10						[illegible] 3-29

Inspection Before [illegible] Date [illegible]
After [illegible] Date [illegible]
Quality Control [illegible] Date 3-28-73
Engineering [illegible] Date 3-28-73

Research Manufacturing Company of Arizona
JALITY CONTROL
REINSPECTION RECORD

PART NUMBER [illegible]-1 C/L C
PART NAME [illegible]
S/N 3-102

Next Assembly ________ C/L ____ Final Assembly ________ S/N ________

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	CONTACT ANGLE		[illegible] / 20°	22°		[illegible]
2	SEPARATOR PILOT CLEARANCE		.020 / .01[illegible]	.016		
3	BALL POCKET CLEARANCE		.02[illegible] / .02[illegible]	.022		
4	BALL SIZE VARIATION		.000[illegible]	.000025		
5	AXIAL CLEAR UNDER [illegible] LOAD		[illegible]	.023		
6						
7						
8						
9						
10						

Inspection Before J. DOUDS Date 3/27/73 Quality Control E. [illegible] Date 4-1-73
After ________ Date ________ Engineering W. E. Williams Date 4-1-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3587?3-2 C/L A
PART NAME BEARING SET

Next Assembly 3740307-2 C/L A Final Assembly 3740301 S/N 2705

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	DIAMETRAL CLC.		.0012 / .0008	.011	.0011	
2	End clearance		.0016 / .0007	.0011	.0011	
3	ROLLER DIA		.2?25 / .275	.2756	.2756	
4	INNER RACE ID		1.57?0 / 1.5745	1.57465	1.57465	
5	AGE OF INNER RACE		.0002	.00005	.00005	
6	DIAMETER INNER RACE		1.850 / 1.846	1.849	1.849	
7	DIAMETER OUTER RACE		2.421 / 2.397	2.401	2.401	
8	P H J OF 2.421-2.397		.0000	.0001	.0001	
9	11 H OF 2.421-2.397		.0001	.0001	.0001	
10						

Inspection Before [illegible] Date 1-?3-73 Quality Control [illegible] Date 4/1/73
After J. DOUDS Date 4/4/73 Engineering W. E. Williams Date 4-1-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740394 C/L
PART NAME GEARSHAFT, SPUR

Next Assembly [illegible] C/L [illegible] S/N 72X7[illegible]

NO.	Dimension and Location		B P	Before	After	Remark
1	Dia -A-			1.3752 / 1.3752	[illegible]	
2	⊥ -A- of -R-		.0002	.0002	[illegible]	
3	// -B-		.0002	.0002	[illegible]	
4	L[illegible]			4.7322	4.722[illegible]	
5						
6						
7						
8						
9						
10						

Inspection Before [signature] Date 3/1/73 Quality Control [signature] Date 3-7-73
After [signature] Date [illegible] Engineering [signature] Date 3-7-73

AiResearch Manufacturing Company of Arizona
QUALITY CONTROL
REINSPECTION RECORD

PART NUMBER 3740292 C/L [illegible]
PART NAME COMBUSTOR ASSEMBLY
REF: 3740291 [illegible]

Next Assembly [illegible] C/L Final Assembly S/N 1480

NO.	Dimension and Location		B P max/min	Before	After	Remark
1	// of A to F	G-4	.002	.5	[illegible]	
2	Diameter	F-4	10.656 / 10.652	10036	[illegible]	
3	⌀ FG of 10.656-10.652	F-4	.002	[illegible]	[illegible]	
4	Seal Diameter	F-8	6.017 / 6.015	6017 / 6016	[illegible]	REF 3740294
5	⌀ FG of Seal Diameter	F-8	.002	.002	[illegible]	REF 3740294
6	Diameter	F-7	[illegible]	2851	[illegible]	REF [illegible]
7	Diameter	F-7	[illegible]	9601 / 2339	[illegible]	REF 37402[illegible]
8	⌀ of 9601 Dia to AB	F-7	.003	.003	[illegible]	REF [illegible]
9						
10						

Inspection Before [signature] Date 3/13/73 Quality Control [signature] Date 3/30/73
After [signature] Date [illegible] Engineering W.F. Williams Date 3-30-73

6.4 Test Logs, Data Sheets, and Recorder Traces

This section contains the test log sheets, data sheets, and recorder traces for the tests run on each engine. The item and page numbers are as follows:

FORM NO. F5330
150 BOOKS 6-72
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona Page No. 1 of ____

QUALIFICATION TEST LOG

E.W.O. No. 3209-4100N-73-0200 Date 4-5-73 Test Cell or Station No. LHCC-2

Assembly No. 3740300-1 Model No. XJ 401 GH-400 Unit Serial No. IPRT 1

Development Engineer D. CHRISTIANSEN Technician STU-WHIT Grp. Ldr. BENNETT

Test Type ____ Test Schedule ____ Modification ____

START TIME	STOP TIME	RUN MIN.	STARTS	TIME	REMARKS
					INSTALL ENG + HOOK UP FOR COMBUSTOR/DIFFUSER
					GREEN RUN CONTROL S/N P-106 T_2 SENSOR 642
					WINDMILL RUN-IN MIN-FLOW 246 PPH PER
					ATP 9030R REV 6 ¶ A, B, C, D, E.
1538			1		SETUP FOR WINDMILL START 40 @ 9500
					TO GOV S/D, ADJ GOV RUN TIME ON CONDITION
	1542	4:16 4:16			120 SEC, TOTAL RUN TIME 256 SEC
					ATP ¶ 4.2.1. A, B, ¶ 4.2.2. A, B, C,
0755			2		D, E, F, G, H, I, J, K, L, M, N, O, P, Q,
	0759	4:03 8:19			RUN TIME 243 SEC R, S,
					ATP ¶ 4.3. A, B, C, D, F, G, H, (20" ABS)
1137	1138	20 8:39	3		I, J, K, L, RUN TIME 20 SEC
					TORQUE MEASURED PER ¶ 4.3 E WAS
					350 IN-LB. ¶ 4.3. M, N, O,
					¶ 6.1. A, B, C,
					SET UP PER QT 9090A ¶ 3.2.2.1.
					A, B, C, D, E, F, G, START COLD SOAK
					@ -65°F ON CONDITION @ 20:00 HRS

QT 100

SUMMARY: Total Running Time ____ hrs. ____ min. Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____ Engineering ____

ORIGINAL

FORM NO. F5530
150 BOOKS 6-72
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona

QUALIFICATION TEST LOG

E.W.O. No. 3209-410019-73-0200 | Date 4-7-73 | Test Cell or Station No. LACC #2

Assembly No. 3940300-1 | Model No. XT 401-6A-400 | Unit Serial No. IFRT # 1

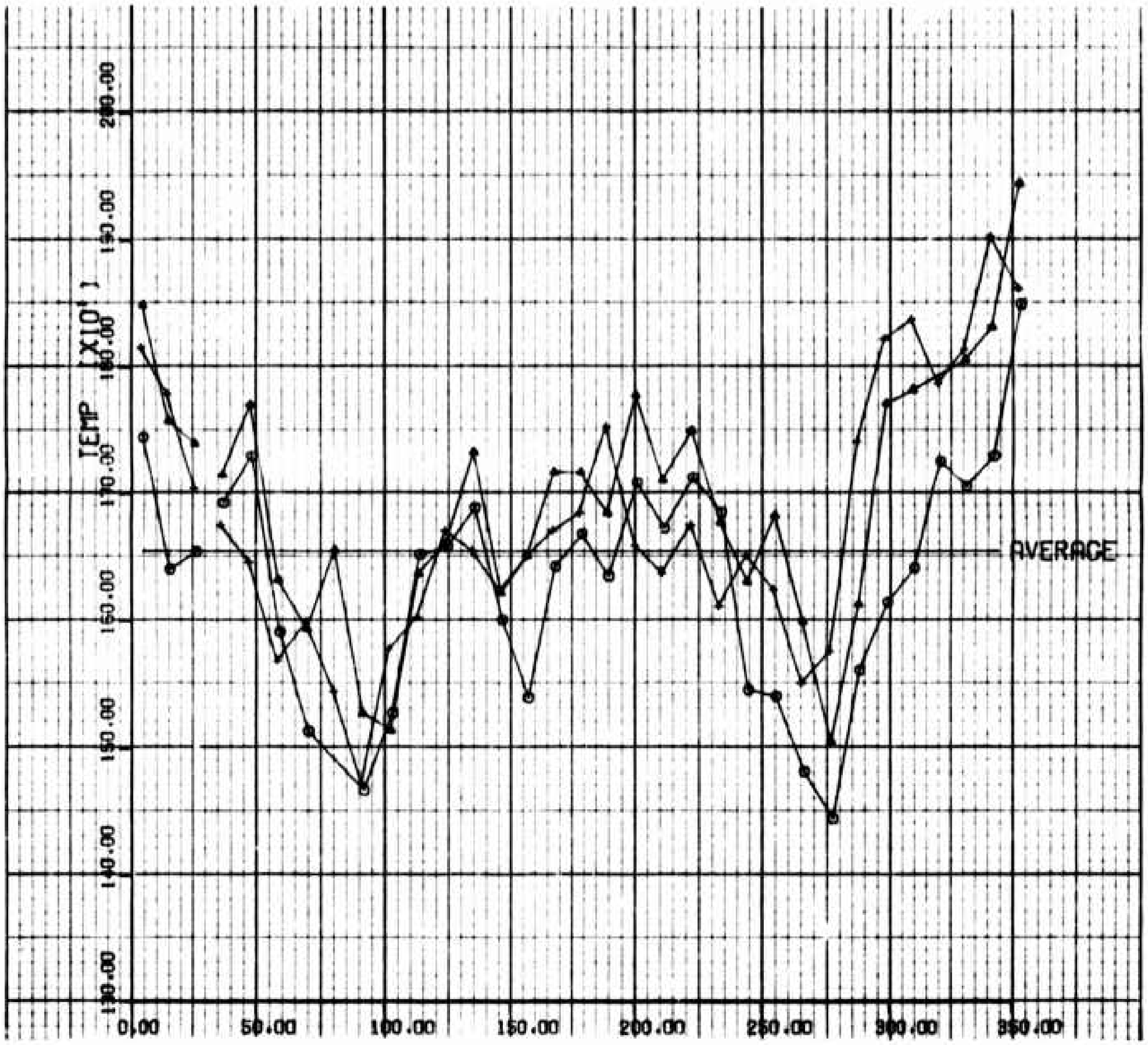
Development Engineer D. Christianson | Technician STU-WHIT | Grp. Ldr. Bennett

Test Type Cold Soak | Test Schedule QT 8090A | Modification

START TIME	STOP TIME	RUN MIN.	STAR	TIME	REMARKS
		05:31	3		FT 170 QC5
					CONTINUE COLD SOAK @ -65°F PER
					QT 8090A ¶ 3.2.2.1. G.
0707	—	115 05:54	4		¶ 3.2.2.2. A, B, C, D, E, F, G, H,
					PYRO SQUIB DID NOT FIRE RUN TIME 15 SEC
					INST NEW STARTER + PYRO
					COLD SOAK ON CONDITION @ 0850 HRS -65°F
					SKIN TEMP
					RE-RUN ¶ 3.2.2.2. A, B, C, D, E, F, G, H,
					STARTER SQUIB FIRED; STARTER DID NOT FIRE
					INST NEW PYRO & STARTER SQUIB
1216			5		RE-RUN ¶ 3.2.2.2. A, B, C, D, E, F, G, H, I,
	1237	20:35 21:29			J, K, L, M, N, O, FT 170 QC5
					TEARDOWN FOR VISUAL INSPECTION, QT 100
					ZYGLO & DIMENSIONAL INSPECTION

SUMMARY: Total Running Time ______ hrs. ______ min. Ref. Data Page ______
Total Manual Starts ______
Total Automatic Starts ______ Engineering ______

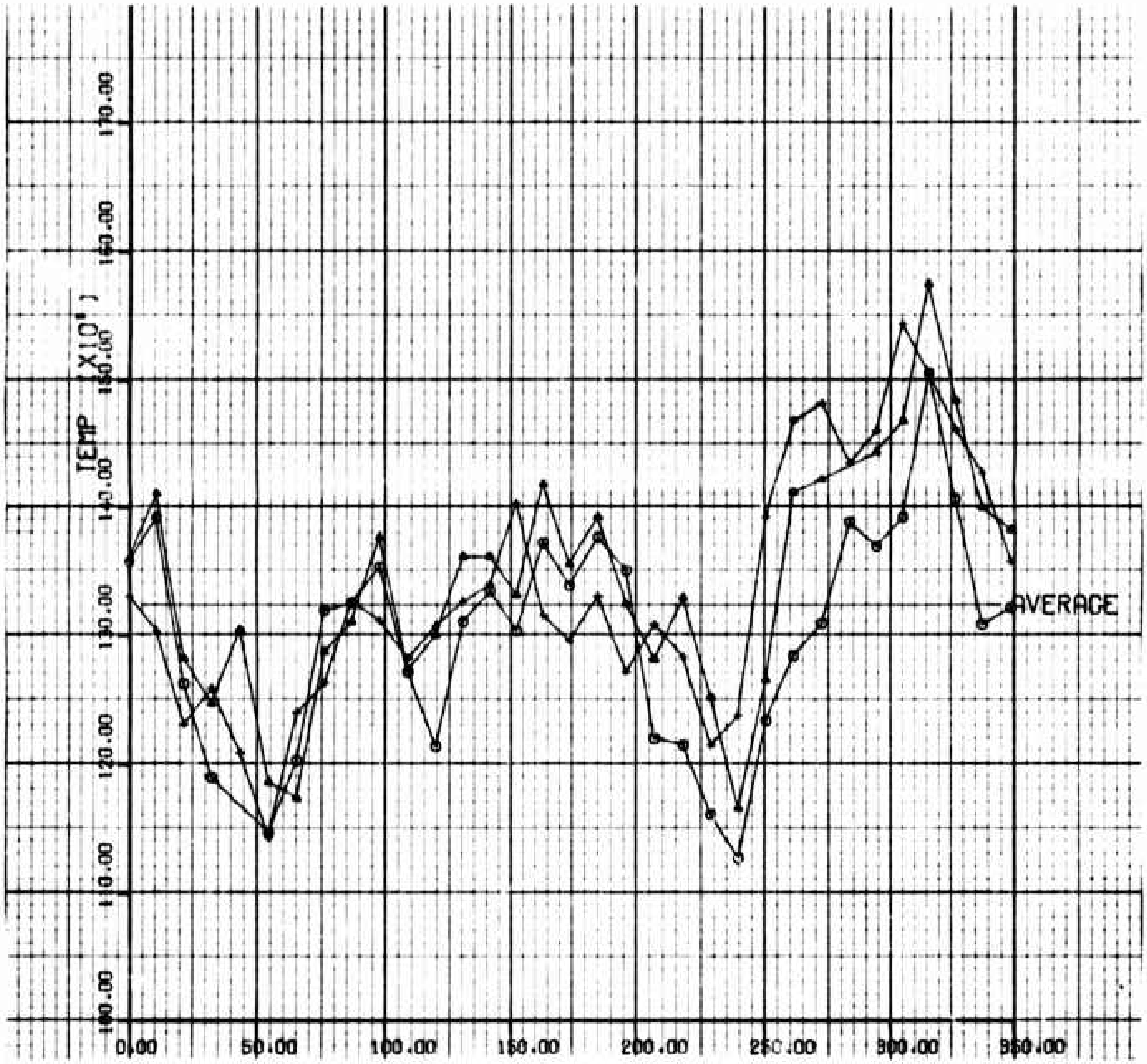
ORIGINAL



ANGLE-DEGREES
MEASURED CLOCKWISE FROM TOP LOOKING AFT

TURBINE INLET TEMPERATURE (T_4) COMPUTED DATA
O = r (3.6 INCHES) Δ = r (4.0 INCHES) + = r (4.4 INCHES)

GREEN RUN ON IFRT ENGINE NO. 1 (4-5-73)
TEMPERATURE SPREAD FACTOR (TSF) = 0.23



ANGLE-DEGREES
MEASURED CLOCKWISE FROM TOP LOOKING AFT

TURBINE DISCHARGE TEMPERATURE (T_5) MEASURED DATA

O = R (3.6 INCHES) Δ = R (4.0 INCHES) + = r (4.4 INCHES)

GREEN RUN ON IFRT ENGINE NO. 1 (4-5-73)
TEMPERATURE SPREAD FACTOR (TSF) = 0.23

MODEL X .1-GA-400

SERIAL NO. 1FRT01 RUN TIME 4:03

DATE 4/6/73 TIME OF DAY 8:00AM

8130
Rev. 3

Barometric pressure	28.84 In. HgA	Start time	9.0 Sec.	At Altitude	20000 Ft
T_{wet}	53 °F	Max. $T_t7.0$	1801 °F		
T_{dry}	68 °F	Engine weight	151 Lbs.		
Fuel specific gravity	.775	Average exhaust nozzle I.D.	5.931 In.		
Speed signal actuation point (alternator load)	30500 rpm	Engine C.G. station	142.7		

Total running time 4:03 min:sec.

LIMITS:

Fuel inlet pressure: 41-65 psia (sea level)
Operating time: Maximum of 4.0 minutes
Electrical load: 3.8 kw minimum 4.0 kw maximum
Vibration: 3.0 mils double amplitude maximum steady state

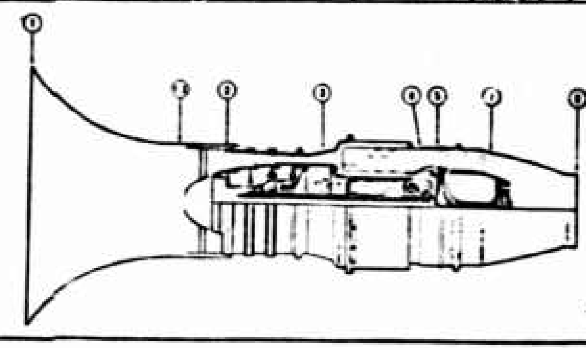
Start Time 18 Seconds max.

Speed signal actuating point: 28,700 rpm to 30,900 rpm.

PERFORMANCE RATING AT SEA-LEVEL ALTITUDE, 90°F AMBIENT CONDITION

	Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	SFC lb/hr/lb of Thrust (Max)	Measured Turbine Discharge Gas Temp. (Max) °F	°C	Airflow Pounds Per Second ±3.0%	Electrical Output kw
a)	Maximum	0.85	599	37,060	1.679	1579	859	13.5	Zero
b)	Maximum	0.85	600	36,960	1.687	1582	861	13.5	3.8

Symbol	Parameter	Units	Perf. Rating (b) (3.8 KW OUTPUT) Measured	Referred Data	Perf. Rating (a) ZERO LOAD OUTPUT Measured	Referred Data
$T_t1.0$	Inlet temperature	°F	172	169	171	169
F_N	Net thrust	Lbs		607		610
N	Speed	Rpm	36619	36619	36615	35545
F_{meas}	Thrust	Lbs	394		392	
$P_t1.2$	Bellmouth total pressure	psig	8.55		8.52	
$P_s1.2$	Bellmouth static pressure	psig	6.98		7.03	
SFC	Specific Fuel Consumption	LB/HR/LB		1.641		1.629
W_a	Airflow	LB/Sec		13.0		12.7
$T_t7.0$	Turbine discharge temperature	°F	1551	1553	1593	1544
A	Output current	Amps	137.7			
V	Output voltage	VDC	29.05			
-	Electrical load	kw		3.8		
W_f	Fuel flow	PPh	950	996	904	981
Vib.	Engine vibration	Mils	1.0		1.6	
$P_{t1.2}-P_{s8}$	Ram ΔP	in. Hg	12.4	12.4	12.35	12.35
M	Mach Number	-	.85	0.85	.85	0.85
Alt.	Altitude	Ft.	1147	S.L.	1153	S.L.



	SIGNATURE	DATE
TECHNICIAN	[signature]	4/6/73
SUPERVISOR	[signature]	4/6/73
QUALITY CONTROL	[signature]	
GOVERNMENT	[signature]	9 Apr 73
ENGINEER	[signature]	4-9-73

FORM NO 3177A

ERT #1

LABORATORY DATA SHEET

Date 4-6-73 Page 1 of Pages

Test Purpose 10 HR COLD SOAK @ -65°F Bar. "Hg Lab. Temp. F. EWO No. 3209-41001I-73-0200

Test Personnel Part No. 3740300-1

Lab. Unit No. S/N 1ERF-1

Dev. Engr. DON CHRISTIANSEN Station No.

INSTR. S/N															
HOUR	SKIN TEMP #16	AMB #1&2 2	HOURS COMPLETED 3	4	5	6	7	8	9	10	11	12	13	14	REMARKS
1 2000	-65°F	-75°F	0	0C3											
2 2100	-67	-74	1.0												
3 2200	-65	-69	2.0												
4 2300	-66	-69	3.0												
5 2400	-66	-68	4.0												
6 0100	-65	-68	5.0												
7 0200	-66	-68	6.0												
8 0300	-65	-67	7.0												
9 0400	-65	-66	8.0												
10 0500	-66	-67	9.0												
11 0600	-66	-66	10.0	[illegible]											
12															
13															
14															
15															
16															
17															
18															
19															
20															

MODEL XJ401-GA-400
SERIAL NO. 1FRTW1 RUN TIME 20.85
DATE 4-7-73 TIME OF DAY 1:45P

Barometric pressure 28.7 in. Hg A
Start time 6.0 Sec.
T_{wet} 47 °F
Max. $T_t7.0$ 1782 °F
T_{dry} 58 °F
Fuel specific gravity .775
Engine weight 151 lbs.
Speed signal actuation point 30500 rpm
Average Exhaust Nozzle I.D. 5.931 In.
Engine C.G. Station 142.7

LIMITS:

Fuel inlet pressure: 29.5-40.0 psia (20,000 ft); 41-46 psia (Sea Level)
Operating time: Min. 16 min. Max. 30 min.
Electrical load: 3.8 kw min. 4.0 kw max.

Start Time: 18 Seconds max.

Speed signal actuating point: 28,700 rpm to 30,900 rpm.

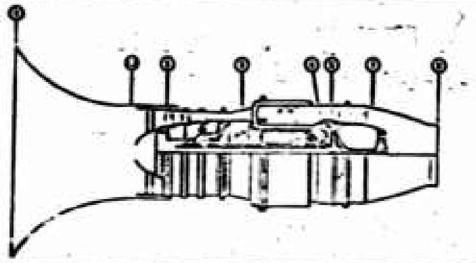
PERFORMANCE RATING AT SEA-LEVEL ALTITUDE, 90°F AMBIENT CONDITION

Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	SFC lb/hr/lb of Thrust (Max)	Measured Turbine Discharge Gas Temp. (Max) °F	°C	Airflow Pounds Per Second ±3.0%	Electrical Output kw
Maximum	0.85	600	36,960	1.687	1582	861	13.5	3.8

Symbol	Parameter	Units	Altitude Condition 1* Measured	Altitude Condition 1* Referred Data	Altitude Condition 2* Measured	Altitude Condition 2* Referred Data	Altitude Condition 3* Measured	Altitude Condition 3* Referred Data	Beginning of Endurance Measured	Beginning of Endurance Referred Data	16 Minutes of Endurance Measured	16 Minutes of Endurance Referred Data	30 Minutes of Operation Measured	30 Minutes of Operation Referred Data
$T_t1.0$	Inlet temperature	°F	-11	-34	+28	+21	179	179	178	169	174	169	173	169
F_N	Net thrust	Lbs		184		285		584		602		619		605
N	Speed	Rpm	30472	28730	22688	22463	36488	36488	36570	36570	36465	36435	36635	36489
F_{meas}	Thrust	Lbs	148		167		266		284		301		238	
$P_t1.2$	Bellmouth total pressure	psig	2.52		4.55		11.67		10.2		10.2		10.3	
$P_s1.2$	Bellmouth static pressure	psig	.98		3.87		9.97		8.8		8.9		8.8	
SFC	Specific Fuel Consumption	LB/HR/LB		1.453		1.581		1.709		1.661		1.631		1.666
W_a	Airflow	LB/Sec		5.3		6.7		13.76		13.02		12.8		12.6
$T_t7.0$	Turbine discharge temperature	°F	943	853	1207	1168	1548	1553	1580	1584	1591	1587	1591	1591
A	Output current	Amps	114		127		126		126		125		125	
V	Output voltage	VDC	26		28		29		29		28.9		28.7	
-	Electrical load	kw		3.0		3.4		3.65		3.65		3.61		3.6
W_f	Fuel flow	PPH	283	267	447	450	985	998	946	1004	959	1009	969	1008
Vib.	Engine vibration	Mils	1.5		1.0		.7		.7		.7		.7	
$P_{t1.2}-P_{s8}$	Ram ΔP	in. Hg	1.88	1.52	9.76	8.53	20.24	19.63	17.4	17.4	17.4	17.4	17.3	17.4
M	Mach Number	-	.43	0.38	.93	0.9	.91	0.9	.856	0.85	.85	0.85	.85	0.85
Alt.	Altitude	Ft.	20031	20,000	21,365	20,000	1354	S.L.	1341	S.L.	1330	S.L.	1342	S.L.

*Refer to Table II for altitude conditions.

Electrical load 3.6 kw vice 3.8 kw min required.



	SIGNATURE	DATE
TECHNICIAN	E. L. Stewart	4/7/73
SUPERVISOR	[illegible]	[illegible]
QUALITY CONTROL	[illegible]	[illegible]
GOVERNMENT	R. P. Burns	9 Apr 73
ENGINEERING	[illegible]	4-9-73

PRESET

DATA SHEET

FLUID: MIL-F-7024A, TYPE II AT 100° ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2262-2
DATE 3/29/73
STAND NO. #3
Pump S/N 216

3.2 BYPASS VALVE SETTING:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	ΔP_{1-2} (PSI) REQD	ΔP_{1-2} (PSI) ACT.	
1	BYPASS VALVE SET	36000	80	69/71	71	SHIM (S-8154-105) UNDER SPRING TO OBTAIN T.P.1.
2	BYPASS VALVE CHECK	28800	80	RECORD	70	

3.3 METERING VALVE SETTING:

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH)	
3	SLOPE SETTING	36000	80	RECORD: 1015	SET SLOPE ADJUST. TO OBTAIN T.P. 5 VALUE OF 590 ±10 PPH
4		36000	40	RECORD: 430	
5	T.P.3 MINUS T.P.4			585	

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH) REQD	FUEL FLOW (PPH) ACT.	
6	LEVEL ADJUST	36000	80	1010±10	1015	SHIM (S-8154-409) SCREW ADJUST.
7	MINIMUM FLOW STOP	21600	15	260 ±3	262	

	Function	Speed (RPM)	Fuel Flow (PPH)	P_3 (PSIA) REQD	P_3 (PSIA) ACT	
8	Minimum Flow ([illegible])	21600	270	32 ±2	32.4	

F 1
303

FINAL

DATA SHEET

TEST FLUID: 7024A, TYPE II @ 100 ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2262-2
DATE 3-29-73
TEST STAND #3
Pump S/N 216

3.5 HYSTERESIS & LINEARITY CHECK:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	P_2 (PSIG)	ΔP_{1-2} (PSI)	FUEL FLOW (PPH) MIN.	ACT.	MAX.
	METERING VALVE:							
8	LINEARITY CHECK	36000	40				430	
9			60				730	
10			80			1000	1015	1020
11			100				1250	
12			120				1380	
13			80				1015	
14			40				430	
15	HYSTERESIS: DIFF. BETWEEN T.P. 10 & 13 SHALL NOT EXCEED 4 PPH.							
16	SLOPE CHECK: DIFF. BETWEEN T.P. 8 & 10 SHALL BE					580	585	600
17	MINIMUM FLOW STOP	21600	15			257	262	263
18	MINIMUM FLOW BREAKAWAY	21600	32.4				270	
19	MAXIMUM FLOW STOP	36000	100			945	950	955

TI-3740425

F 303

POST IFRT #1 FINDINGS

PRESET LAB MAX FLOW PLUG

DATA SHEET

FLUID: MIL-F-7024A, TYPE II AT 100° ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2262-2
DATE 4/9/73
STAND NO. #3

3.2 BYPASS VALVE SETTING:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	ΔP_{1-2} (PSI) REQD	ΔP_{1-2} (PSI) ACT.	
1	BYPASS VALVE SET	36000	80	69/71	70	SHIM (S-8154-105) UNDER SPRING TO OBTAIN T.P.1.
2	BYPASS VALVE CHECK	28800	80	RECORD	68	

3.3 METERING VALVE SETTING:

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH)	
3	SLOPE SETTING	36000	80	RECORD: 1020	SET SLOPE ADJUST. TO OBTAIN T.P. 5 VALUE OF 590 ±10 PPH
4		36000	40	RECORD: 440	
5	T.P.3 MINUS T.P.4			580	

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH) REQD	FUEL FLOW (PPH) ACT.	
6	LEVEL ADJUST	36000	80	1010±10	1020	SHIM (S-8154-409) SCREW ADJUST.
7	MINIMUM FLOW STOP	21600	15	260 ±3	263	

	FUNCTION	SPEED (RPM)	FUEL FLOW (PPH)	P (PSIA) REQD	P (PSIA) ACT	
8	Minimum Flow [illegible]	21600	270	32±2	32	

TI-3740425

FT 308

DS-3740425, Rev. 1
11-20-72

POST IFRT #4 FINDINGS ASREC'D

FINAL

DATA SHEET

TEST FLUID: 7024A, TYPE II @ 100 ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2262-2
DATE 4-9-73
TEST STAND #3
Pump S/N 216

3.5 HYSTERESIS & LINEARITY CHECK:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	P_1 (PSIG)	ΔP_{1-2} (PSI)	FUEL FLOW (PPH) MIN.	ACT.	MAX.
	METERING VALVE:							
8	LINEARITY CHECK	36000	40				440	
9			60				735	
10			80			1000	955	1020
11			100				955	
12			120				950	
13			80				955	
14			40				438	
15	HYSTERESIS: DIFF. BETWEEN T.P. 10 & 13 SHALL NOT EXCEED 4 PPH.							
16	SLOPE CHECK: DIFF. BETWEEN T.P. 8 & 10 SHALL BE					580	—	600
17	MINIMUM FLOW STOP	21600	15			257	263	263
18	Minimum Flow Breakaway	21600	32				270	
19	Minimum Flow Stop	36000	100			945	955	955

FT 309

TI-3740425

DS-3740427, Rev. 1
11-21-72

DATA SHEET

TEST STAND #3
P/N 3740427-1
S/N 009
DATE 2-12-73

TEST FLUID: DRY, FILTERED AIR @ 80° ±40°F

① PAR. 3.2 - CONTINUITY CHECK ☑

COIL RESISTANCE: 190 OHMS
APPROXIMATELY 180-216

TEST POINT	T.I. PARAGRAPH	CALIBRATION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA) MIN	P_x (PSIA) ACT	P_x (PSIA) MAX
②	3.3.3	SET NOZZLE TO OBTAIN	90	+10	82.6	82.6	83.6
③	3.3.3	SLOPE CHECK POINT	90	+30	68.0		70.0

④ PAR. 3.3.3 - FINAL ORIFICE (d_o) DIAMETER: .0292 INCH.

TEST POINT	T.I. PARAGRAPH	FUNCTION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA) MIN	P_x (PSIA) ACT	P_x (PSIA) MAX
5	3.4	Linearity & hysteresis	90	-10	-	90	-
6				0	-	87.2	-
7				10	82.6	82.6	83.6
8				20	-	76.6	-
9				30	68.0	69.9	70.0
10				40	-	62.9	-
11				50		55.7	55.5
12				60	-	48.7	-
13				50		55.7	55.5
14				40	-	62.8	-
15				30	68.0	69.8	70.0
16				20	-	76.6	-
17				10	82.6	82.6	84.6
18				0	-	87.2	-
19				-10	-	90.0	-

TECH [signature] FT 308
Q.C. ____________

DS-3740427, Rev. 1
11-21-72

POST IFRT #1 FINDINGS

DATA SHEET

TEST FLUID: DRY, FILTERED AIR @ 80° ±40°F

TEST STAND #3
P/N 3740427-1
S/N 009
DATE 4/9/73

① PAR. 3.2 - CONTINUITY CHECK ☑

COIL RESISTANCE: 190 OHMS
APPROXIMATELY 180-216

TEST POINT	T.I. PARAGRAPH	CALIBRATION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA)		
					MIN	ACT	MAX
②	3.3.3	SET NOZZLE TO OBTAIN	90	+10	82.6	83.3	83.6
③	3.3.3	SLOPE CHECK POINT	90	+30	68.0	70	70.0

④ PAR. 3.3.3 - FINAL ORIFICE (d_o) DIAMETER: .0292 INCH.

TEST POINT	T.I. PARAGRAPH	FUNCTION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA)		
					MIN	ACT	MAX
5	3.4	Linearity & hysteresis	90	-10	-	89.5	-
6				0	-	88.2	-
7				10	82.6	83.3	83.6
8				20	-	77.0	-
9				30	68.0	70.0	70.0
10				40	-	62.4	-
11				50	X	54.2	55.5
12				60	-	47.0	-
13				50	X	54.2	55.5
14				40	-	62.5	-
15				30	68.0	70.0	70.0
16				20	-	77.2	-
17				10	82.6	83.4	84.6
18				0	-	88.2	-
19			↓	-10	-	89.5	-

TECH [signature] FT 308

Q.C. ________________

FA133-1

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

OIL & FUEL ANALYSIS 14341

MATERIALS ENGINEERING

APR 18 1973

Requestor D CHASTAIN Dept. 93-17
Copies To
Manufacturer
Date 4-6-73

Customer
Engine Serial No. IFRT # 1
Operating Hours
Sample Origin
Charge No.
Date Required 4-9-73

☐ B. P. Distillation

IBP °F
5%
10%
20%
30%
40%
50%
60%
70%
80%
90%
95%
E.P.
% Distilled

% @ 400°F

☐ Flash Point

COC °F

☐ T.A.N.

☒ L.H.V.

18,570 BTU/LB

☐ Other

☒ Specific Gravity

51.0 API @ 60°F
0.775 @ 60°F

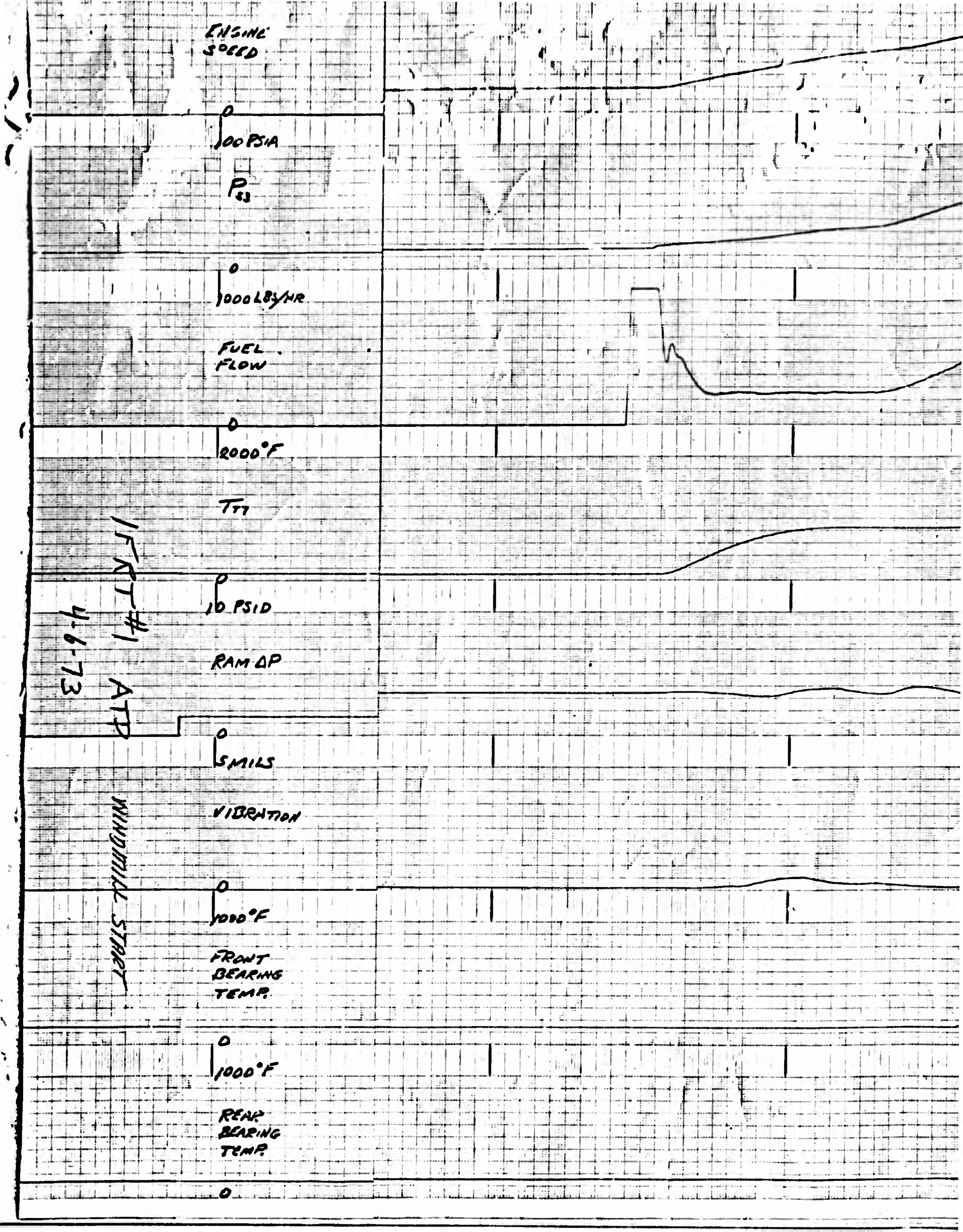
IFRT # 1

☐ Reid Vap. Press. psi

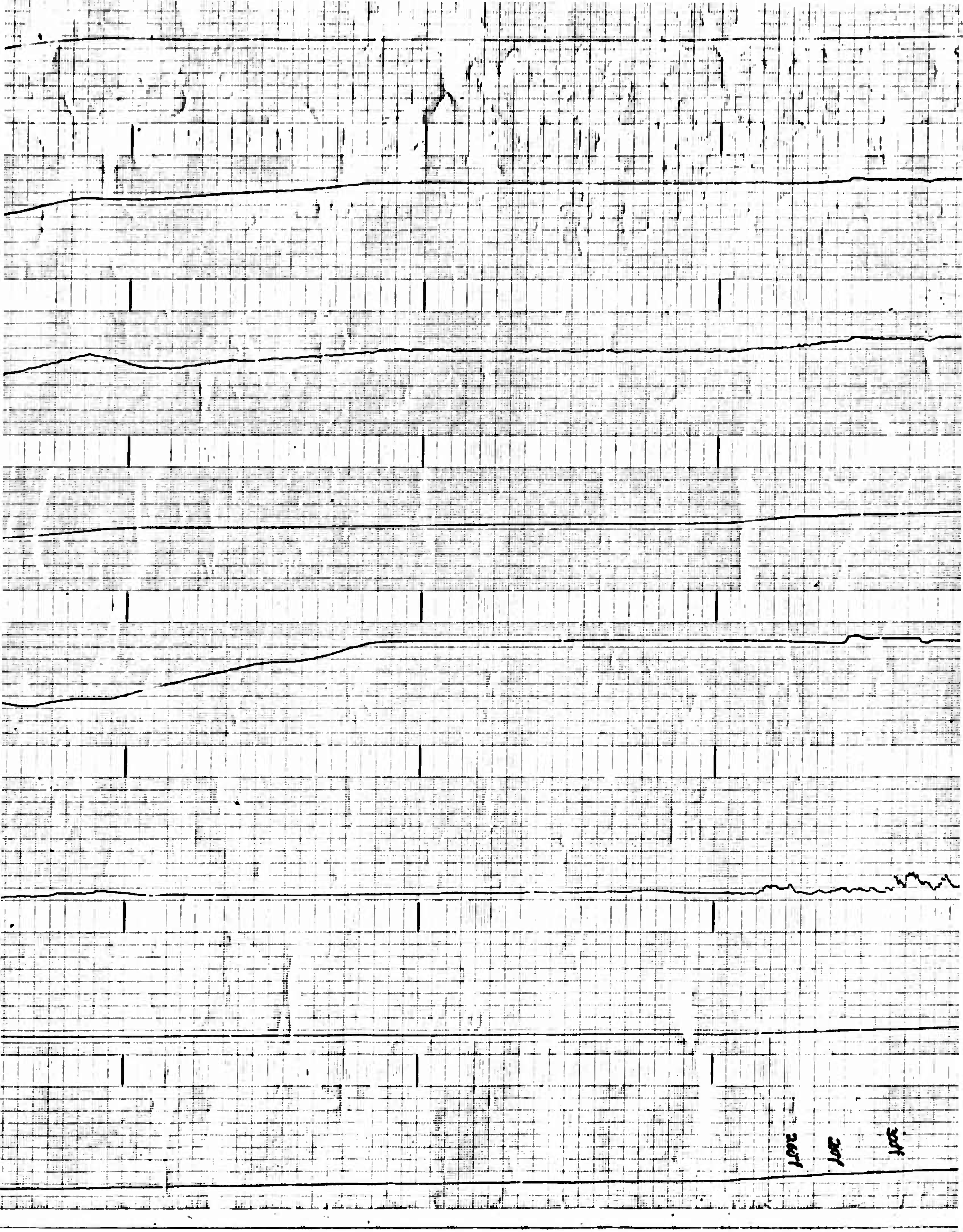
☐ Viscosity

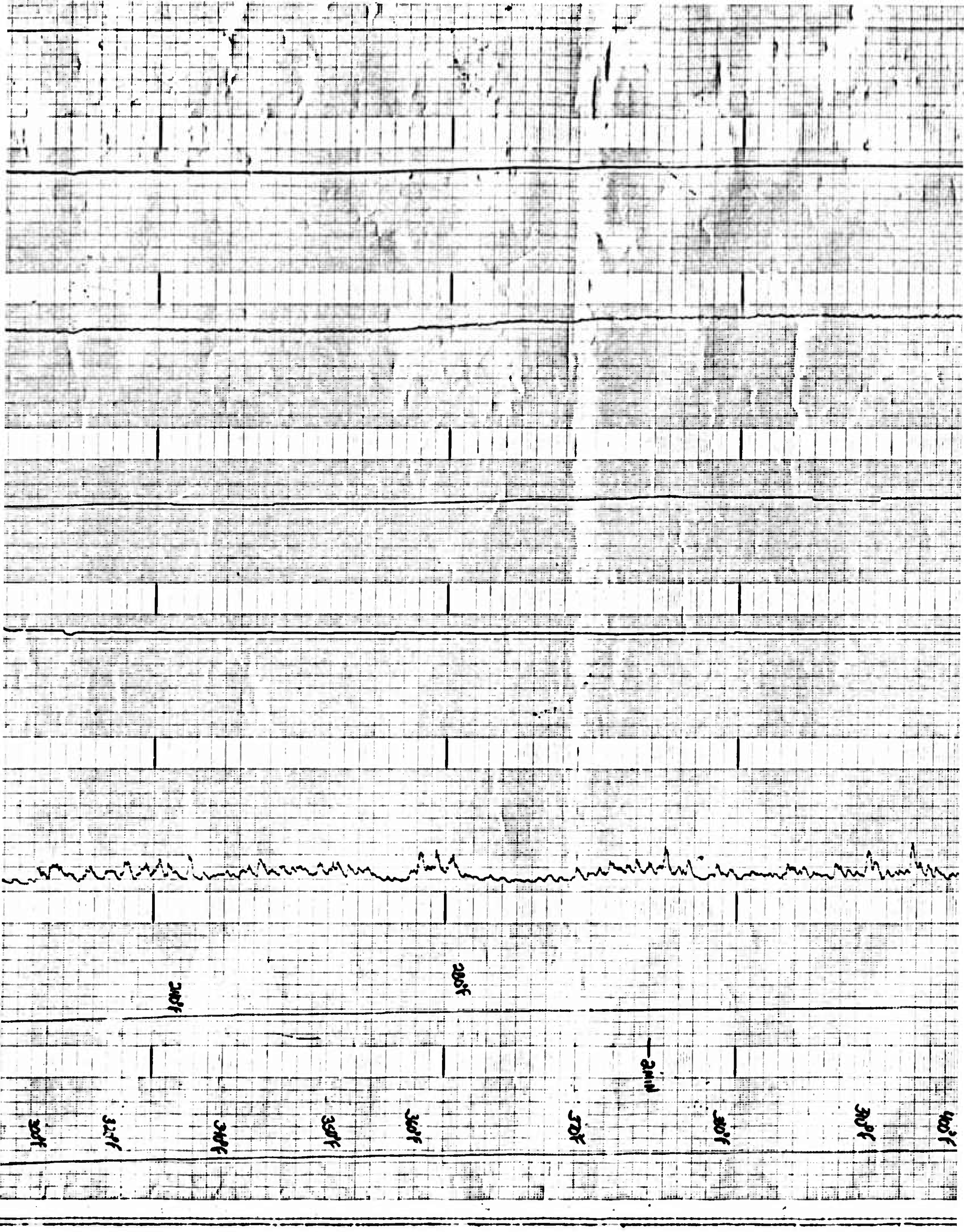
cs.	@ °F
	77
	100
	210

Analyst [signature]

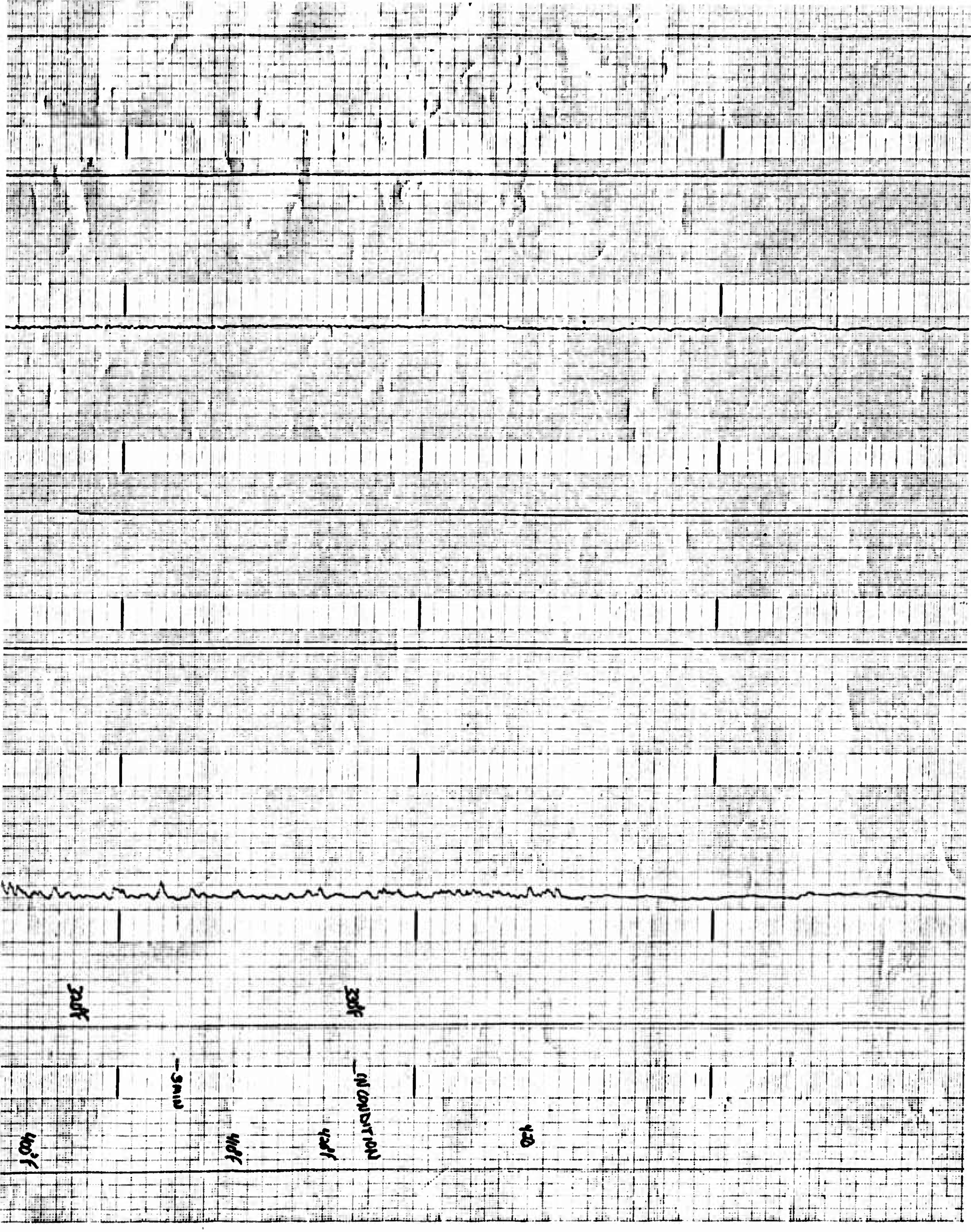


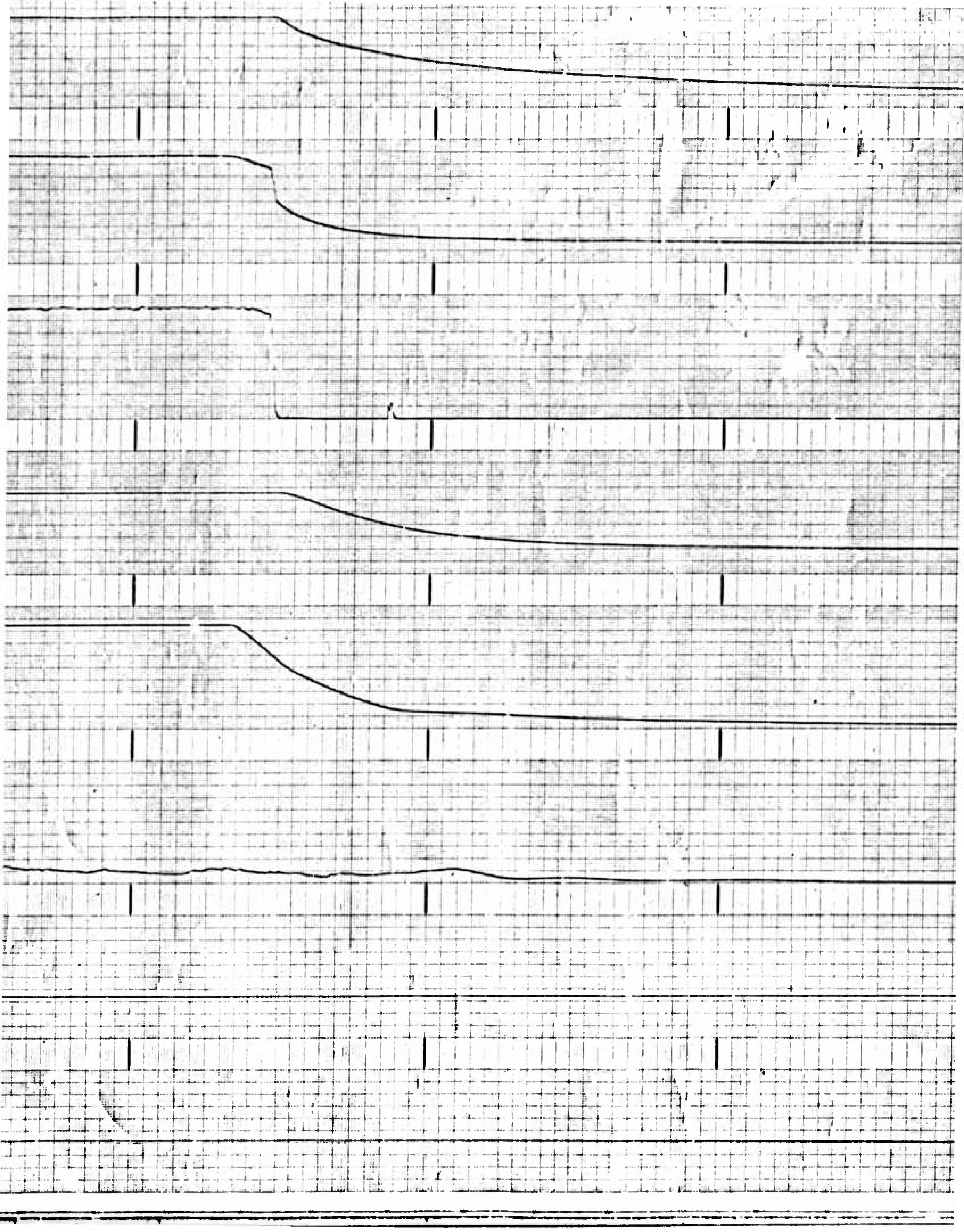
ENGINE SPEED
0
100 PSIA
P_{S3}
0
1000 LBS/HR
FUEL FLOW
0
2000°F
T_{T7}
0
10 PSID
RAM ΔP
0
5 MILS
VIBRATION
0
1000°F
FRONT BEARING TEMP.
0
1000°F
REAR BEARING TEMP.
0
IFRT #1 ATP
4-6-73
WINDMILL START

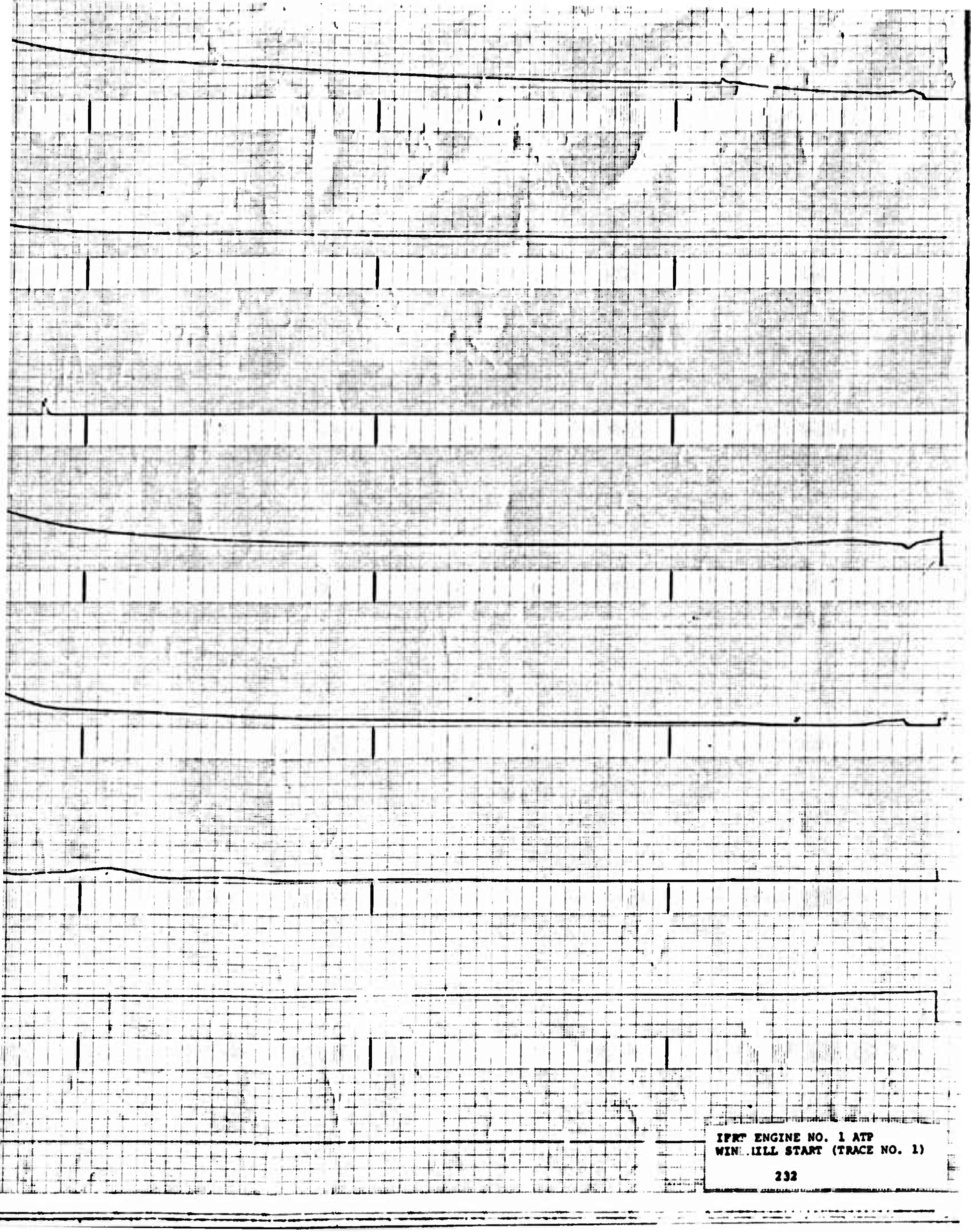




340°F
280°F
2 min
300°F
320°F
340°F
350°F
360°F
370°F
380°F
390°F
400°F

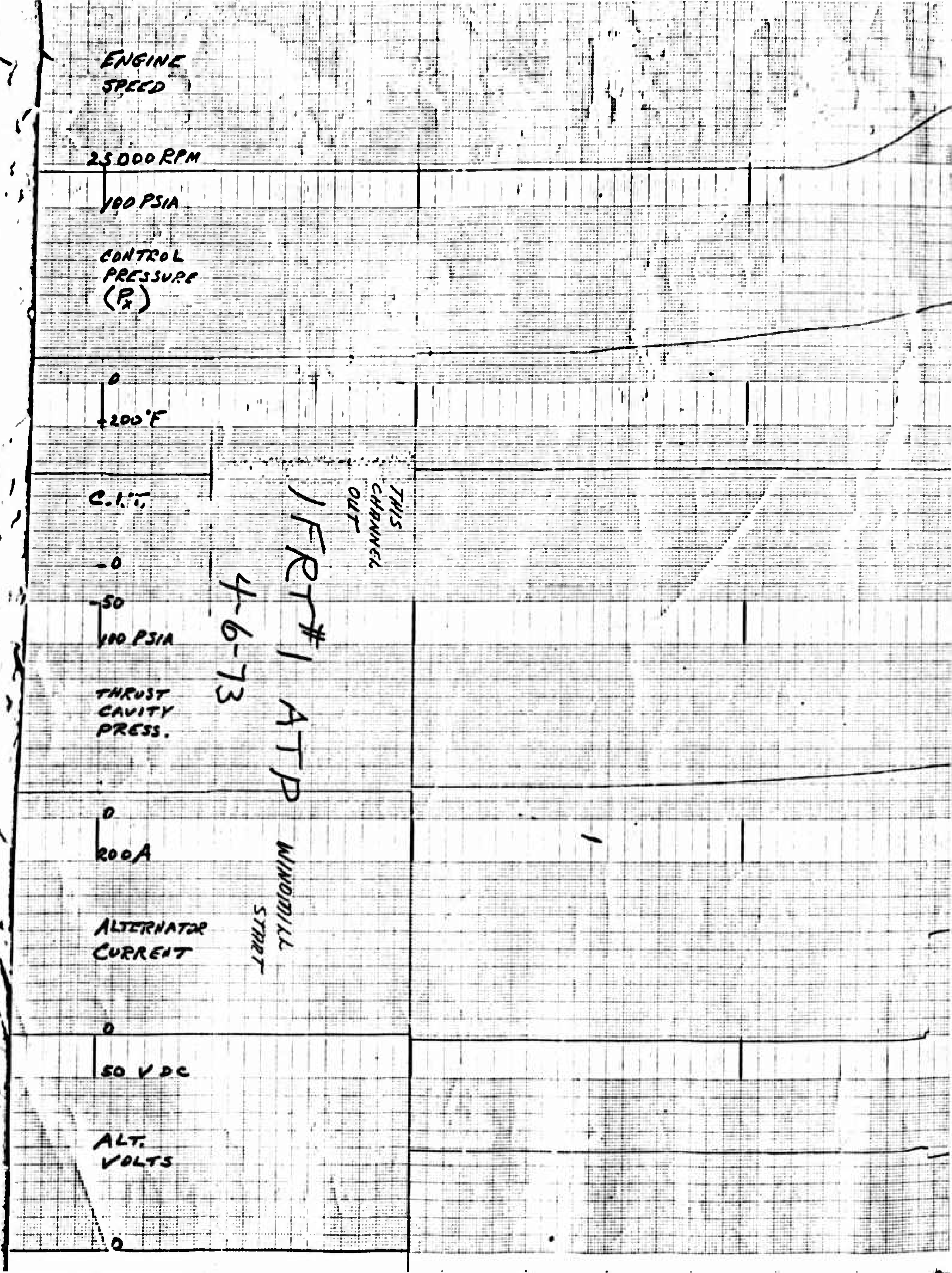

300°F
300°F
-3 MIN
IN CONDITION
400°F
410°F
420°F
420

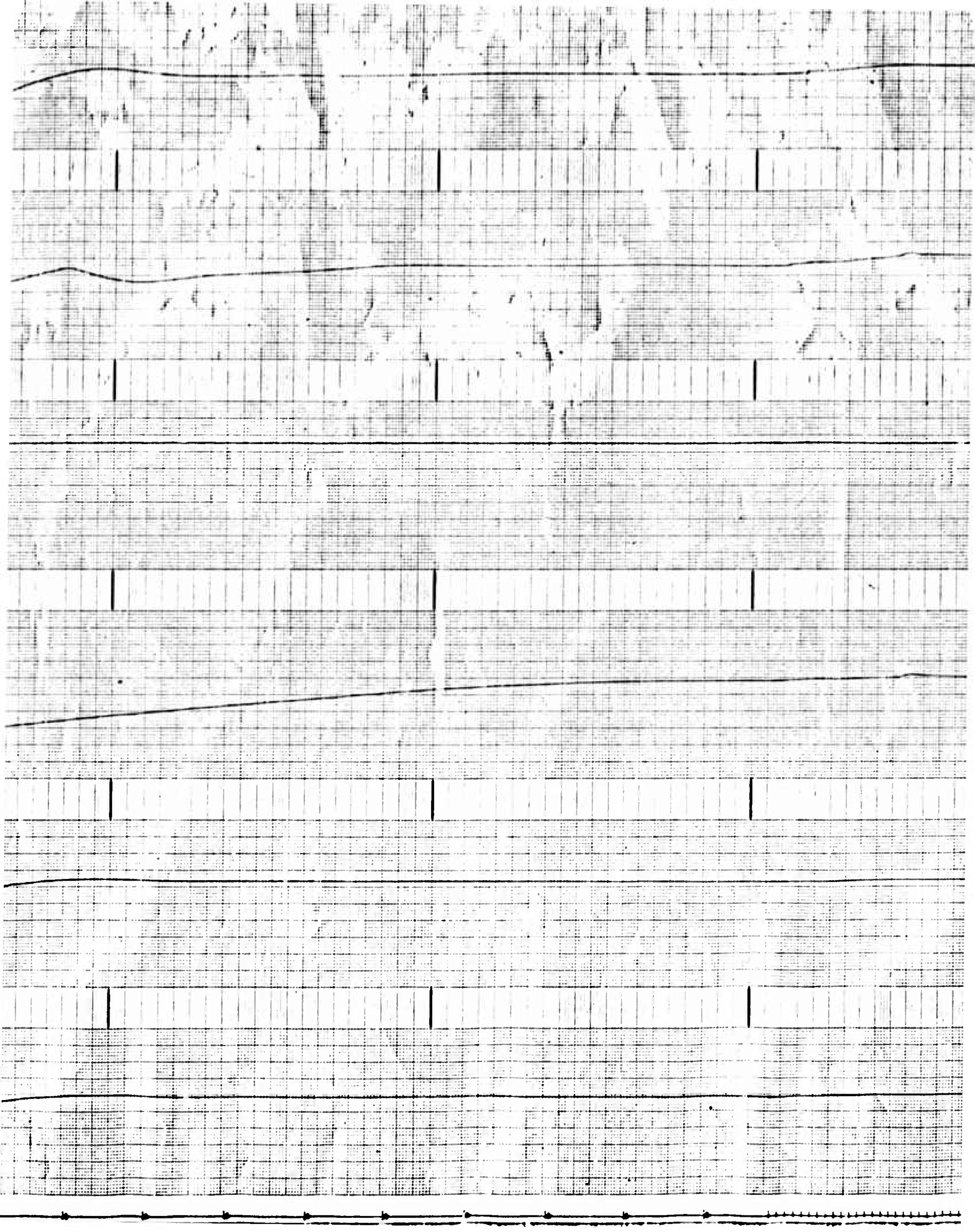


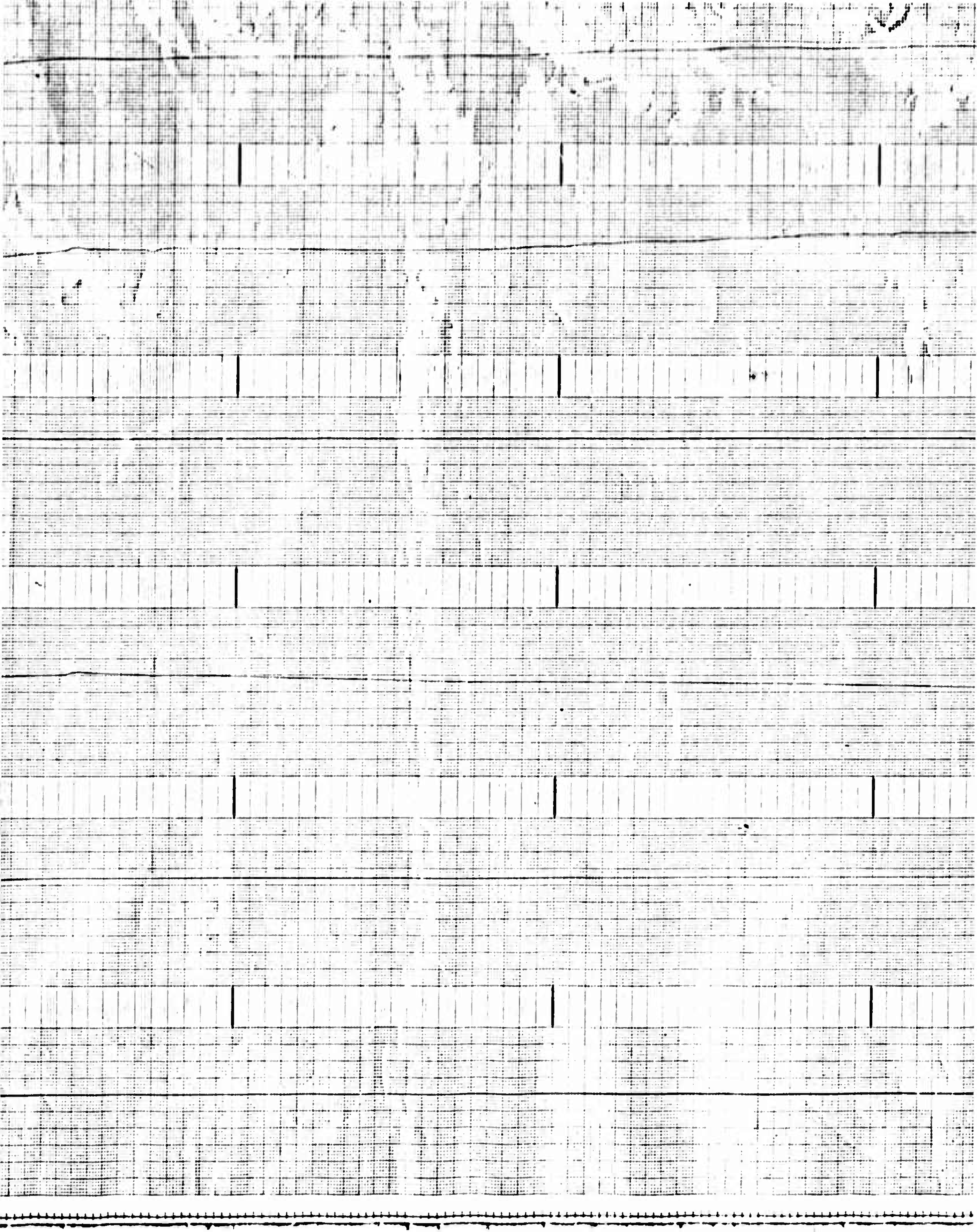


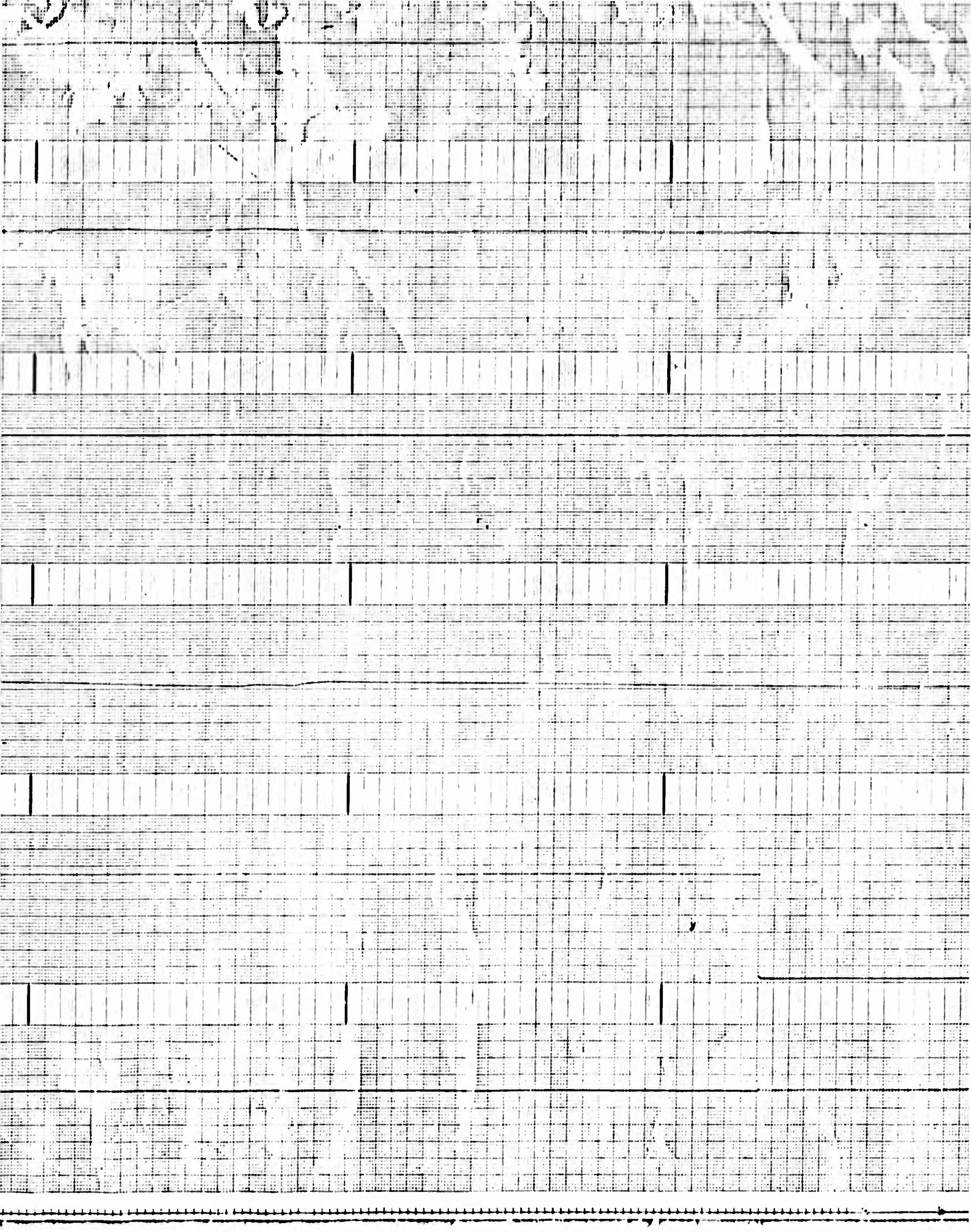
IFRT ENGINE NO. 1 ATP
WINDMILL START (TRACE NO. 1)

232


ENGINE SPEED
25000 RPM
100 PSIA
CONTROL PRESSURE (P_x)
0
200°F
C.I.T.
0
50
100 PSIA
THRUST CAVITY PRESS.
0
200A
ALTERNATOR CURRENT
0
50 VDC
ALT. VOLTS
0
THIS CHANNEL OUT
IFRT#1 ATP
4-6-73
WINDMILL START

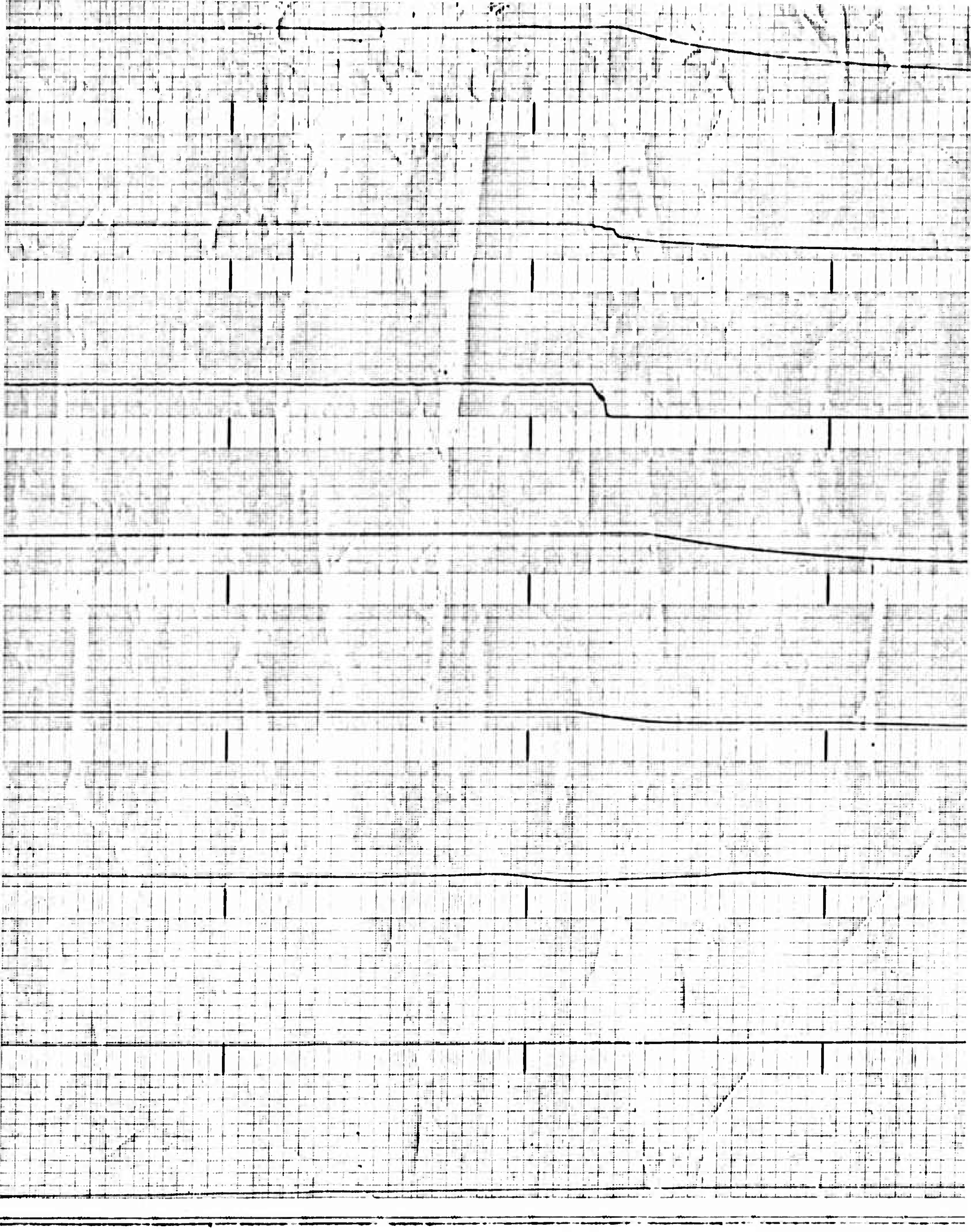


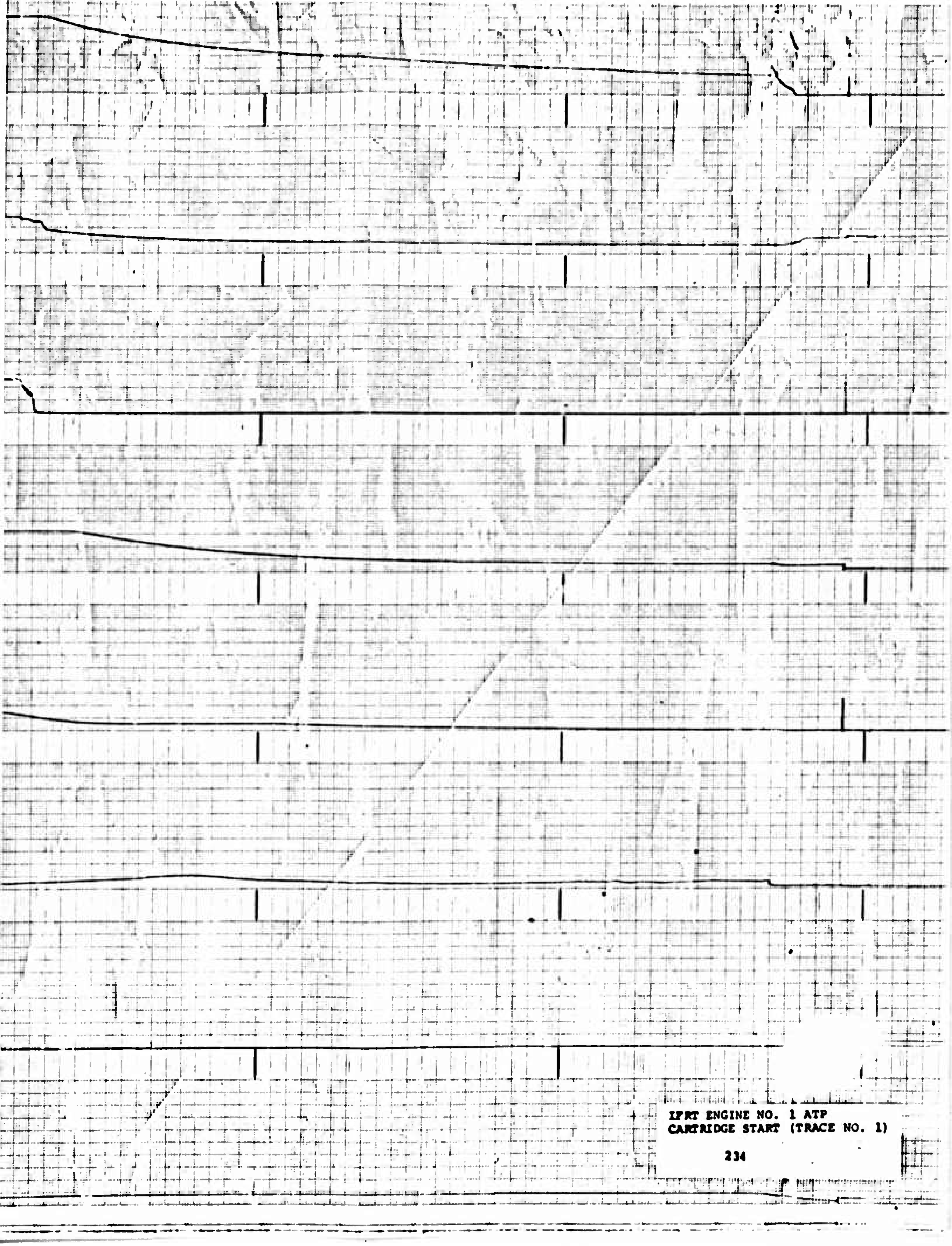




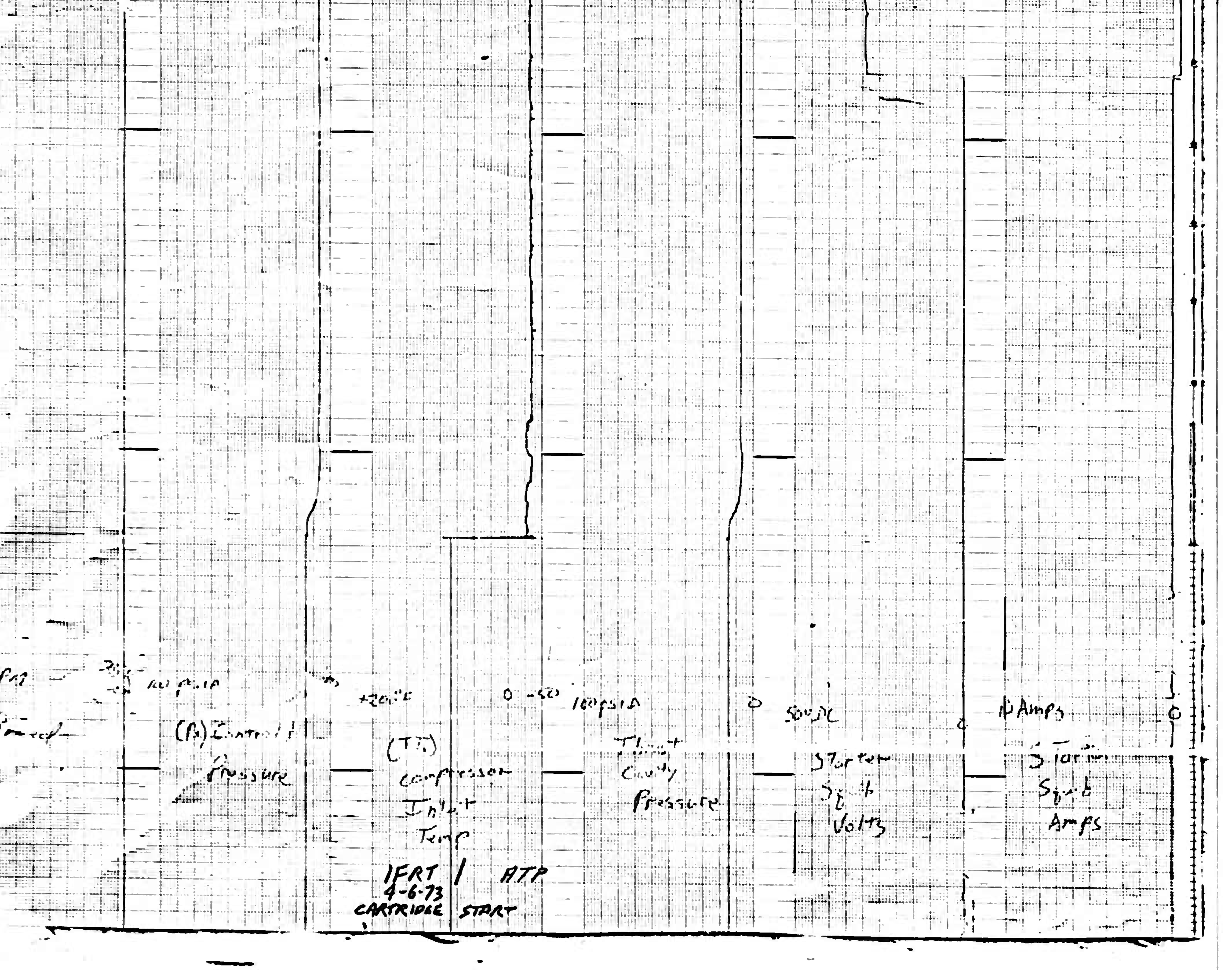
IFRT ENGINE NO. 1 ATP
WINDMILL START (TRACE NO. 2)

RPM
Speed
0
10 PSIA
P_{S3}
0
10 PPH
(wf)
Fuel Flow
0
2000°F
T_{T7}
0
10 PSID
Ram ΔP
0
5 mil
Vibration
0
100°F
Front Bearing Temp
0
1000°C
Rear Bearing Temp
IFRT 1
4-6-73
CARTRIDGE START
ATP

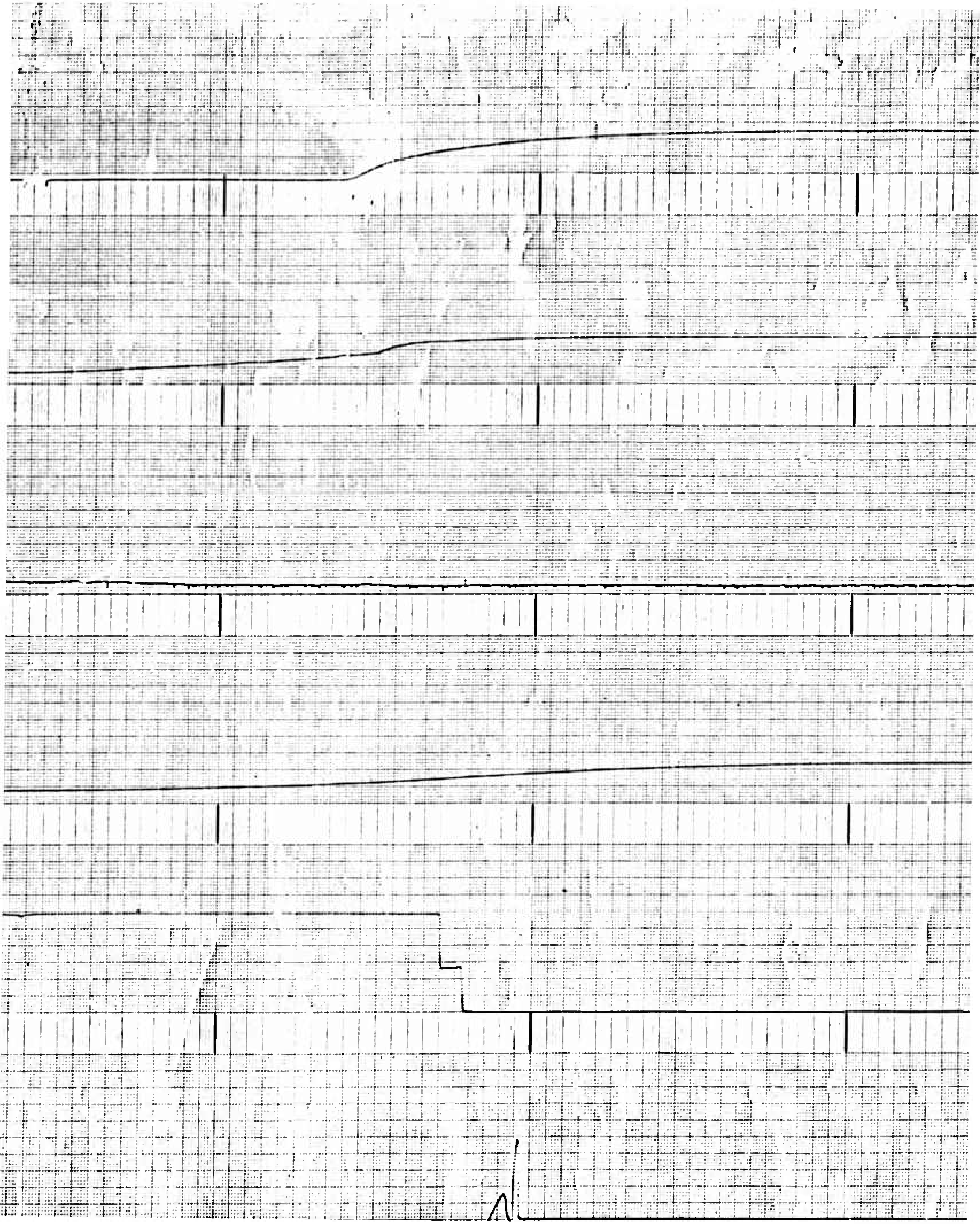




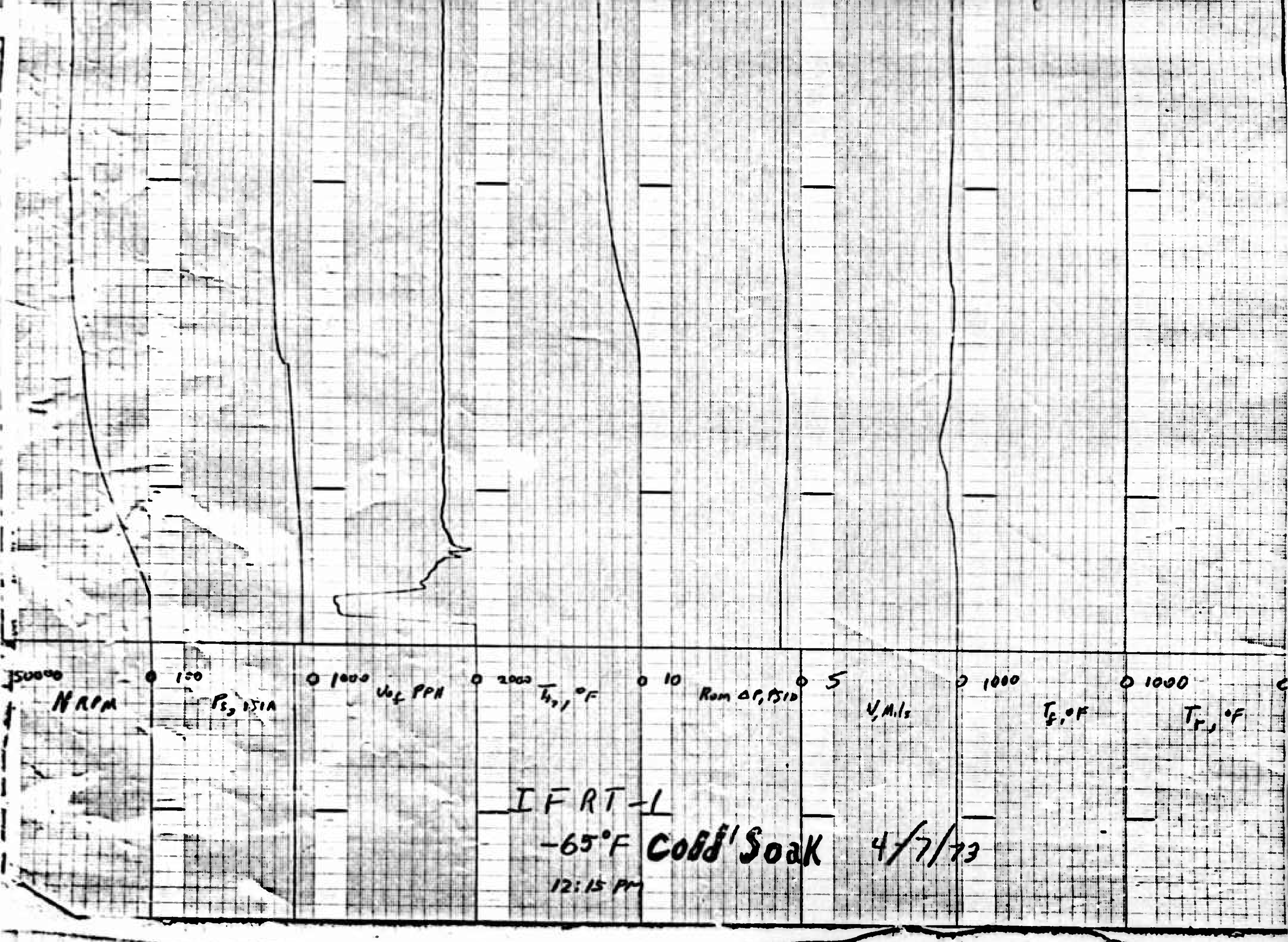
IFRT ENGINE NO. 1 ATP
CARTRIDGE START (TRACE NO. 1)



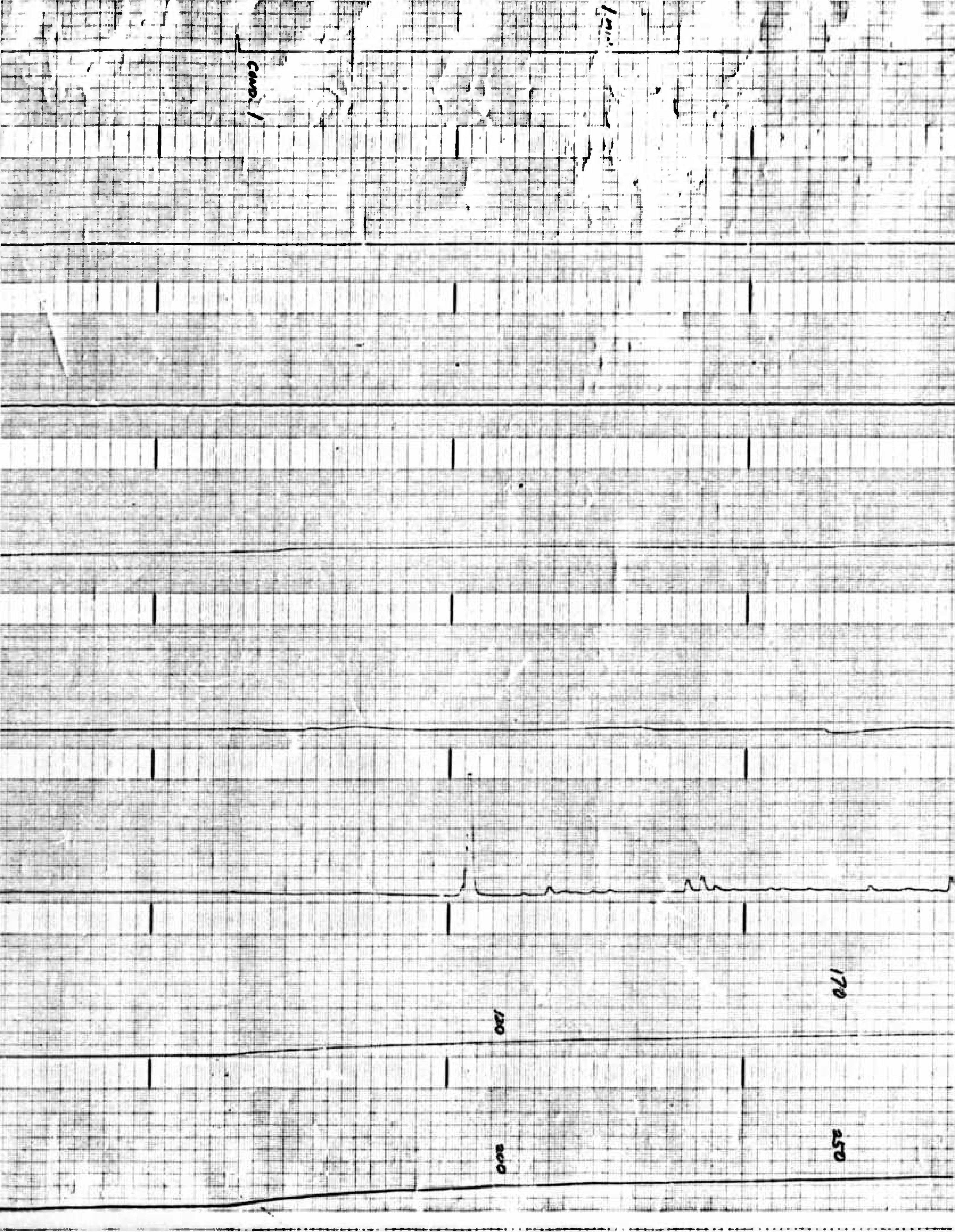
(Pc) Control Pressure
+200°C
(T?) Compressor Inlet Temp
0 -50
100 psiA
Thrust Cavity Pressure
0
50 VDC
Starter Gen Volts
0
Starter Gen Amps
0
IFRT / ATP
4-6-73
CARTRIDGE START

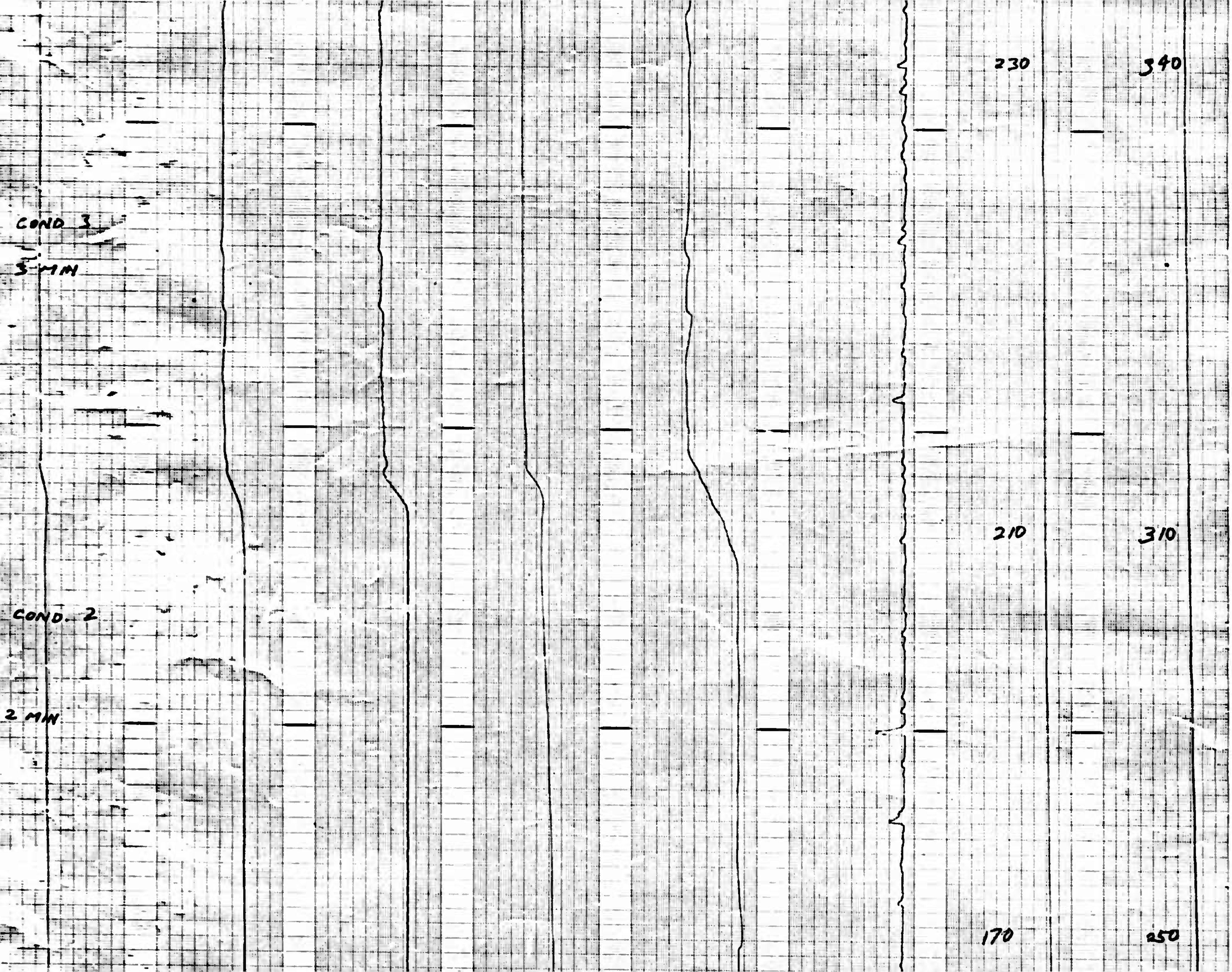


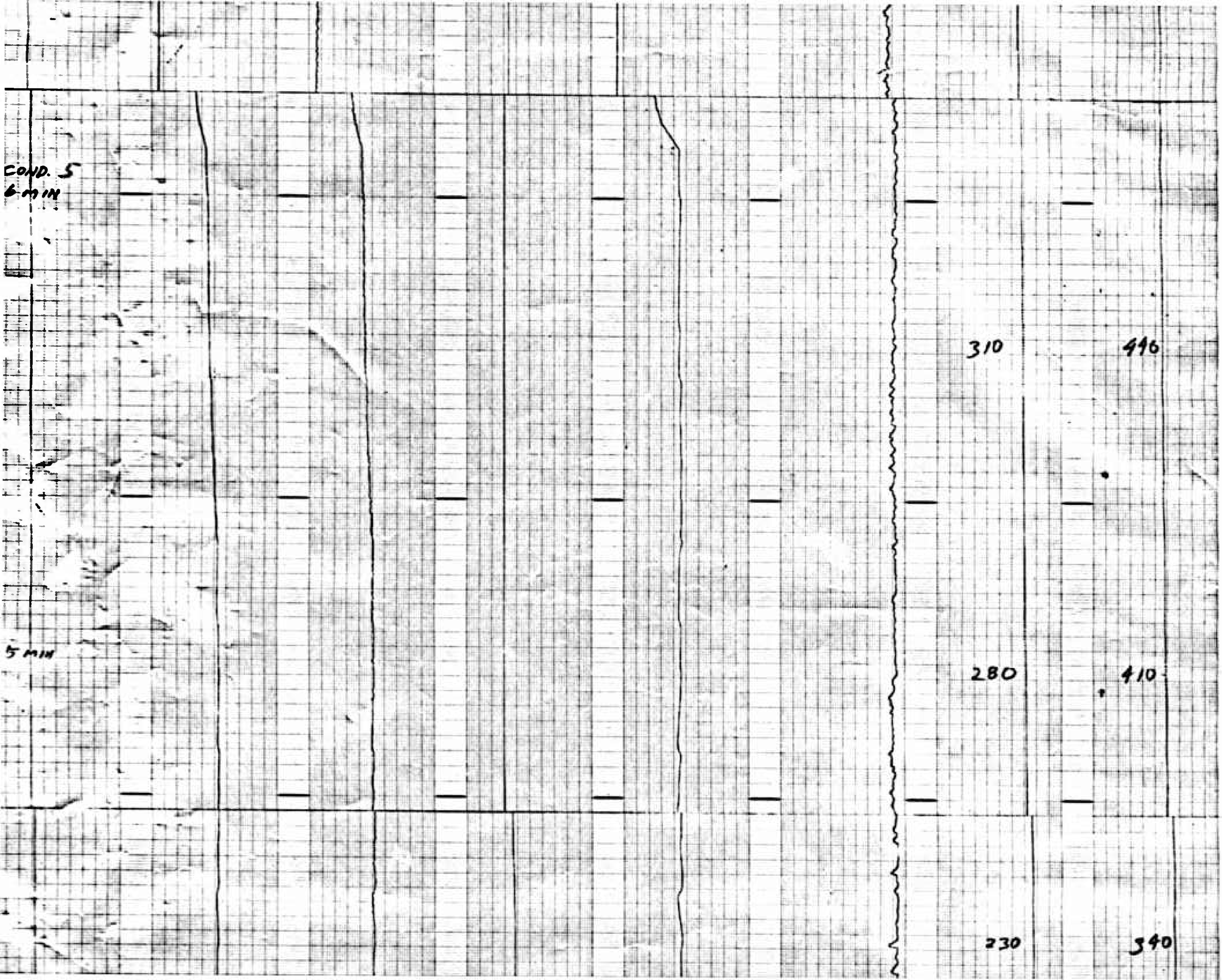
IFRT ENGINE NO. 1 ATP
CARTRIDGE START (TRACE NO. 2)

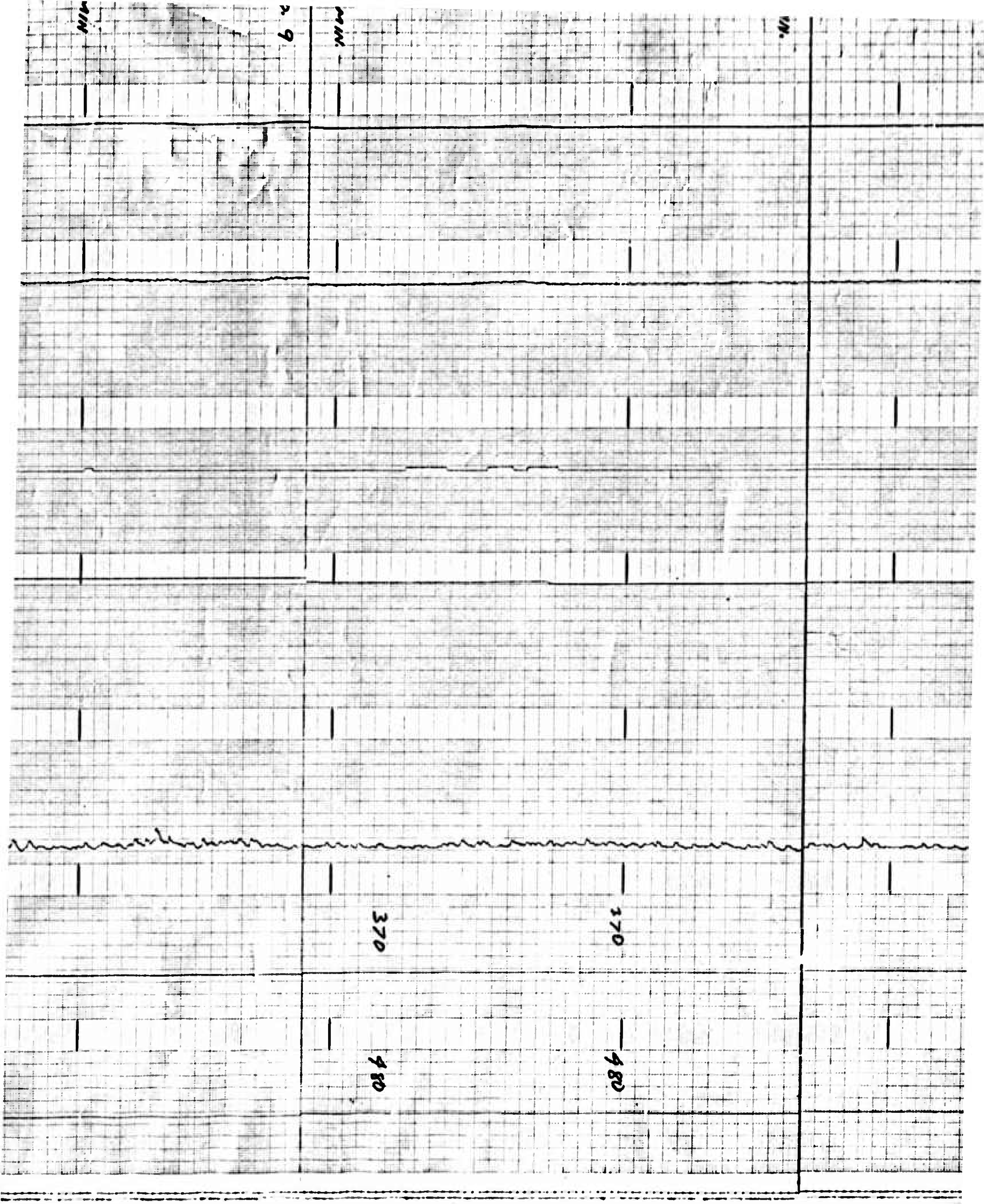


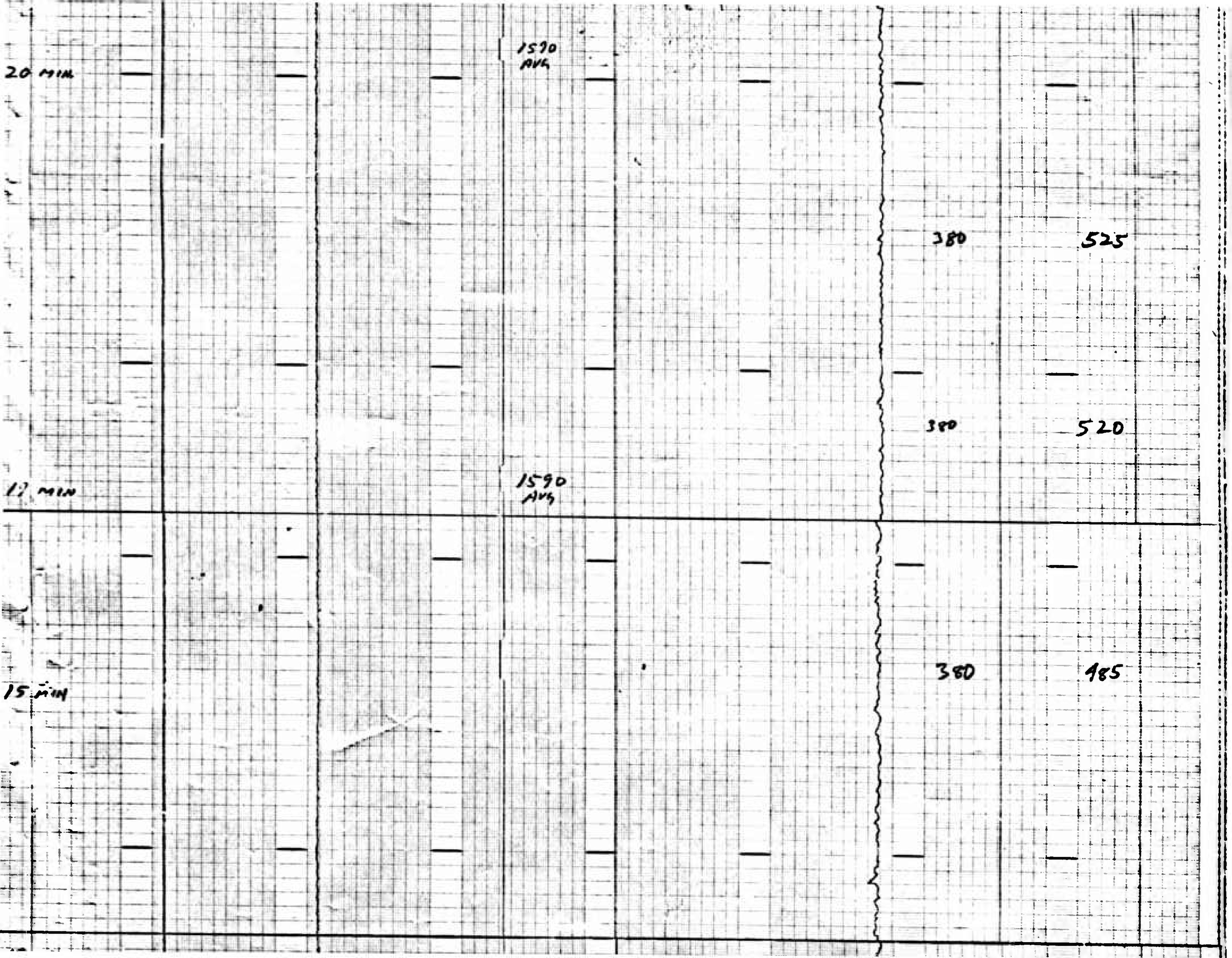
50000
N RPM
0 150
P_{s_3} PSIA
0 1000
W_f PPH
0 2000
T_{t_7} °F
0 10
Rom ΔP, PSID
0 5
V, Mils
0 1000
T_f, °F
0 1000
T_r, °F
IFRT-1
-65°F Cold Soak 4/7/73
12:15 PM


cont'd
1 min
170
200
250

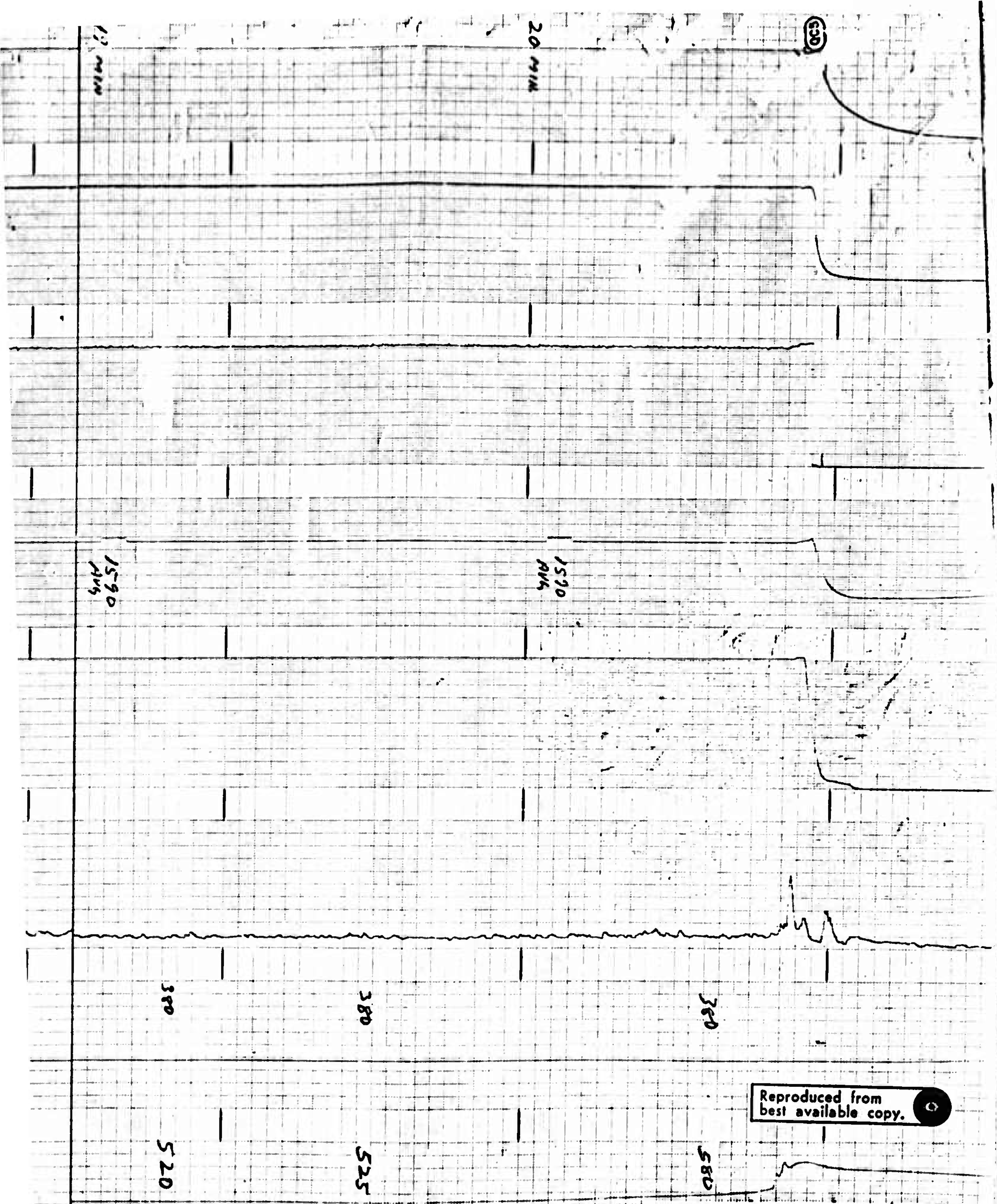

230
340
COND 3
3 MIN
210
310
COND. 2
2 MIN
170
250


COND. 5
6 MIN
5 MIN
310
446
280
410
230
340

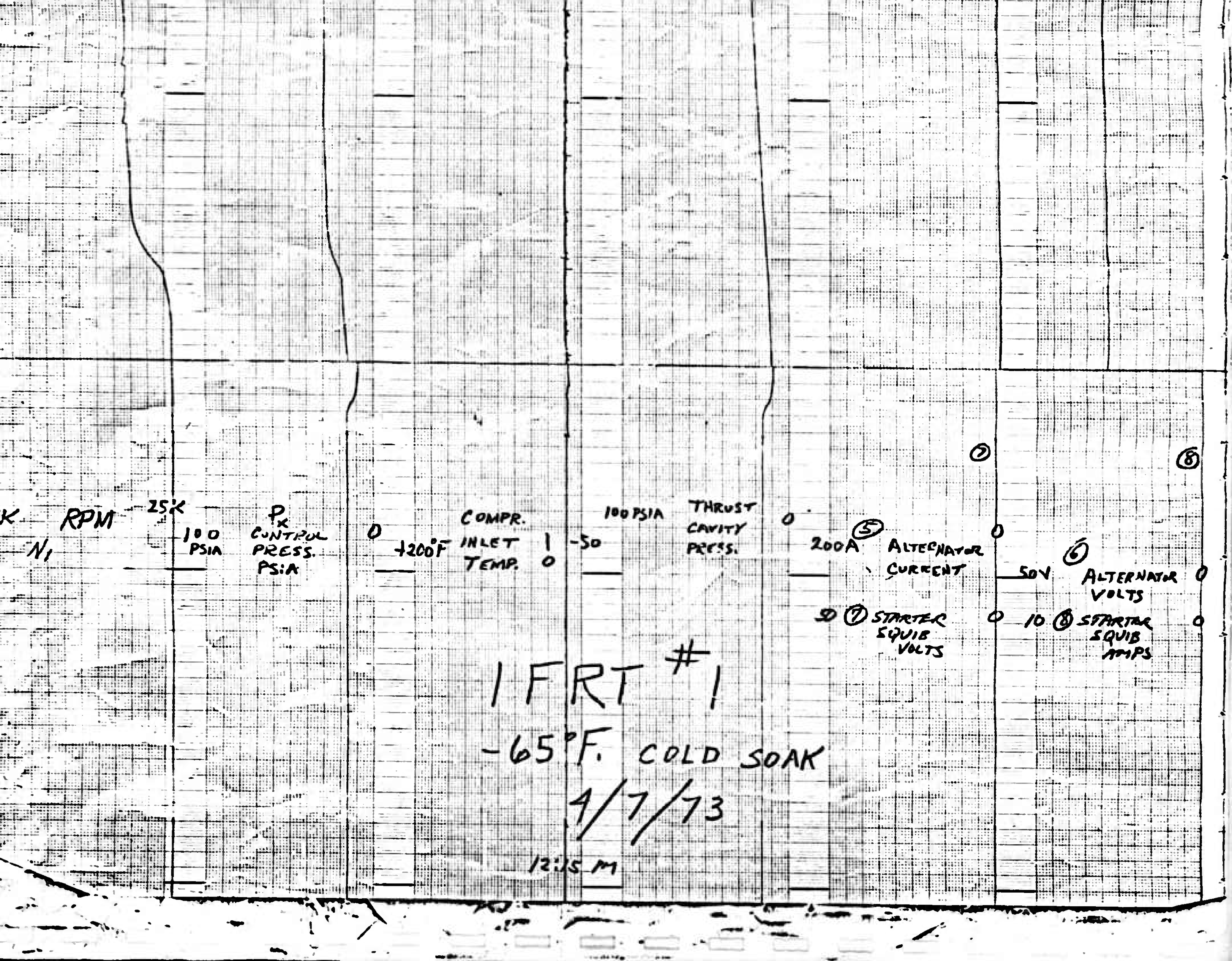

MIN
MIN
370
370
480
480

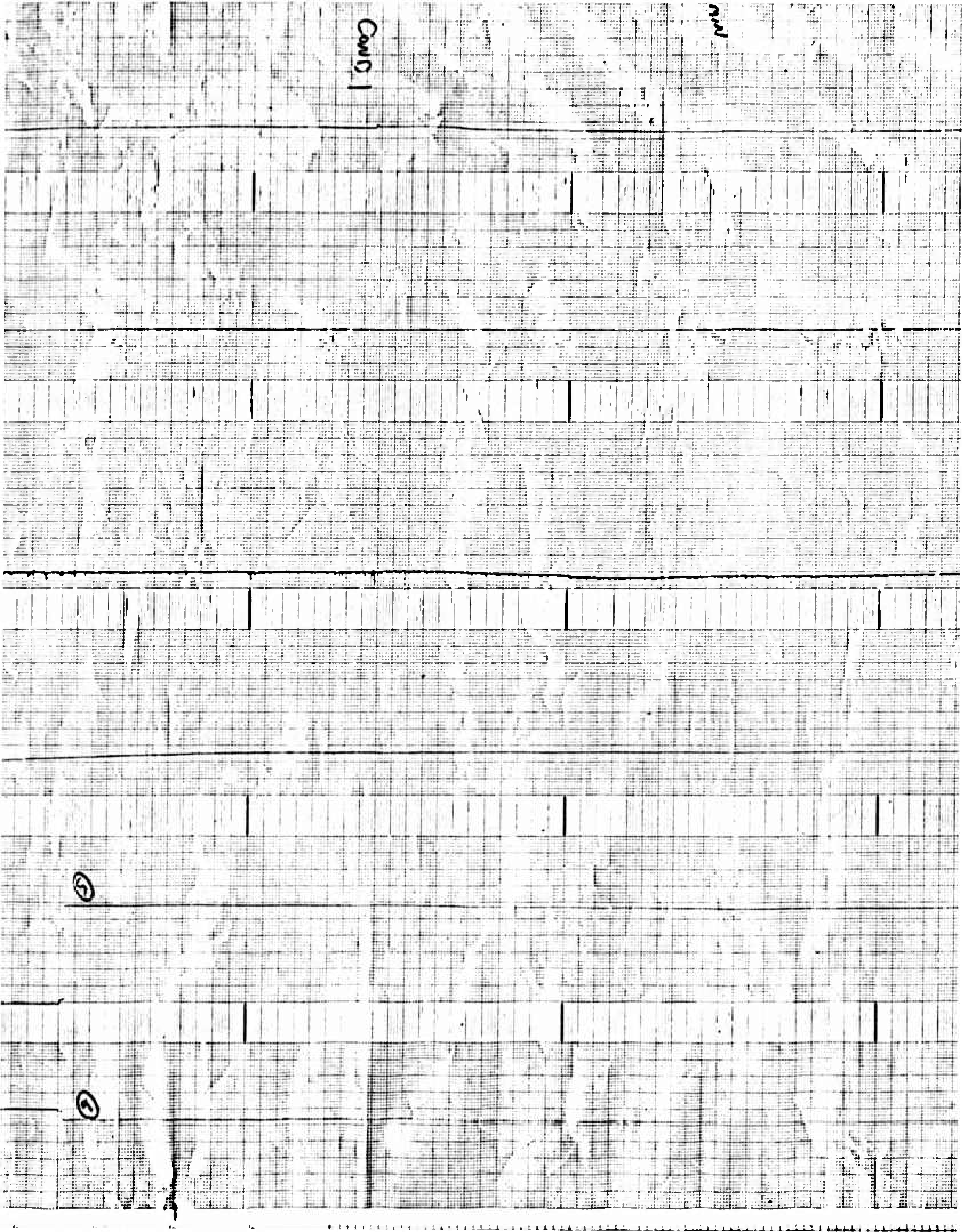


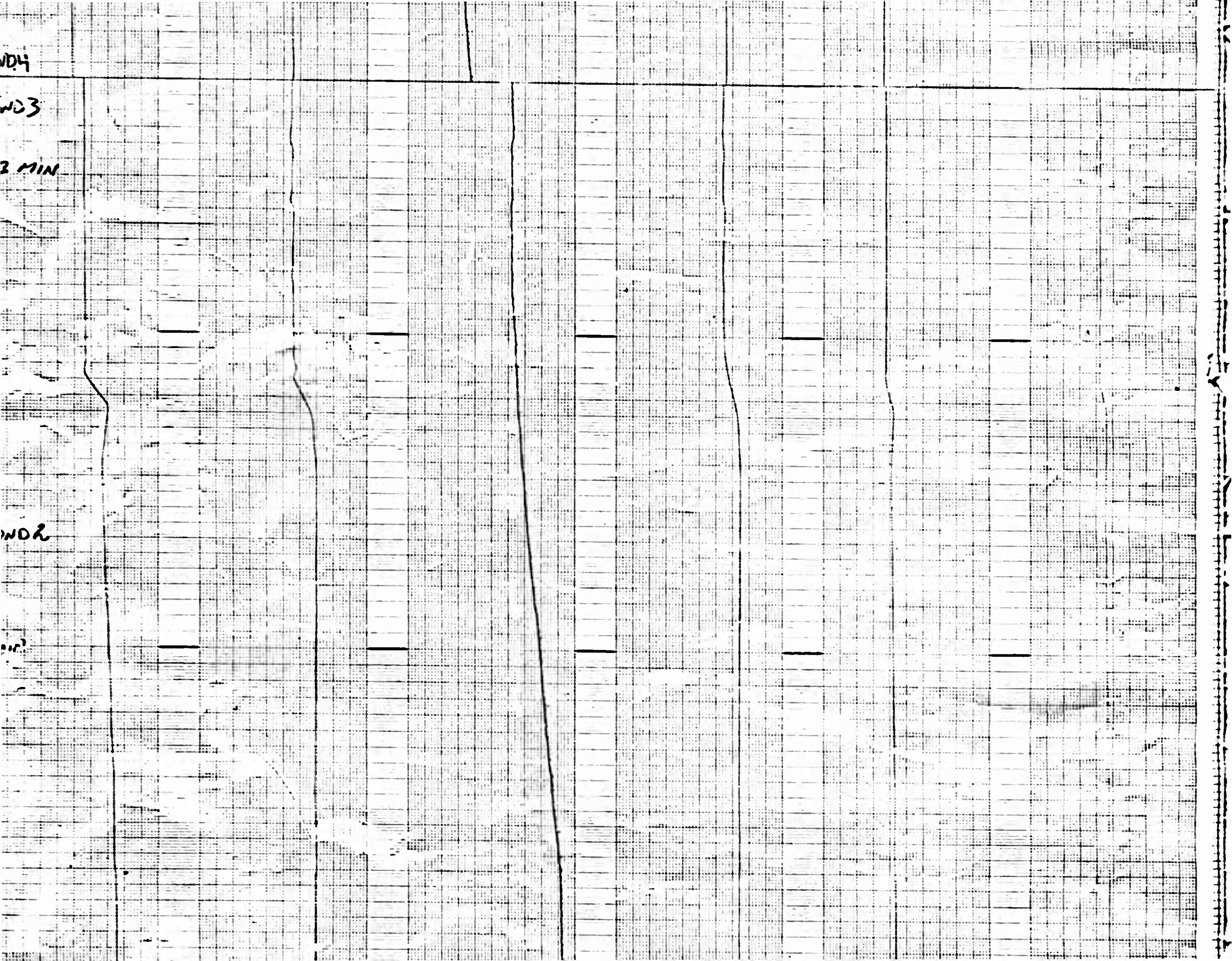
20 MIN
1590 AVG
1590 AVG
15 MIN
380
525
380
520
380
485

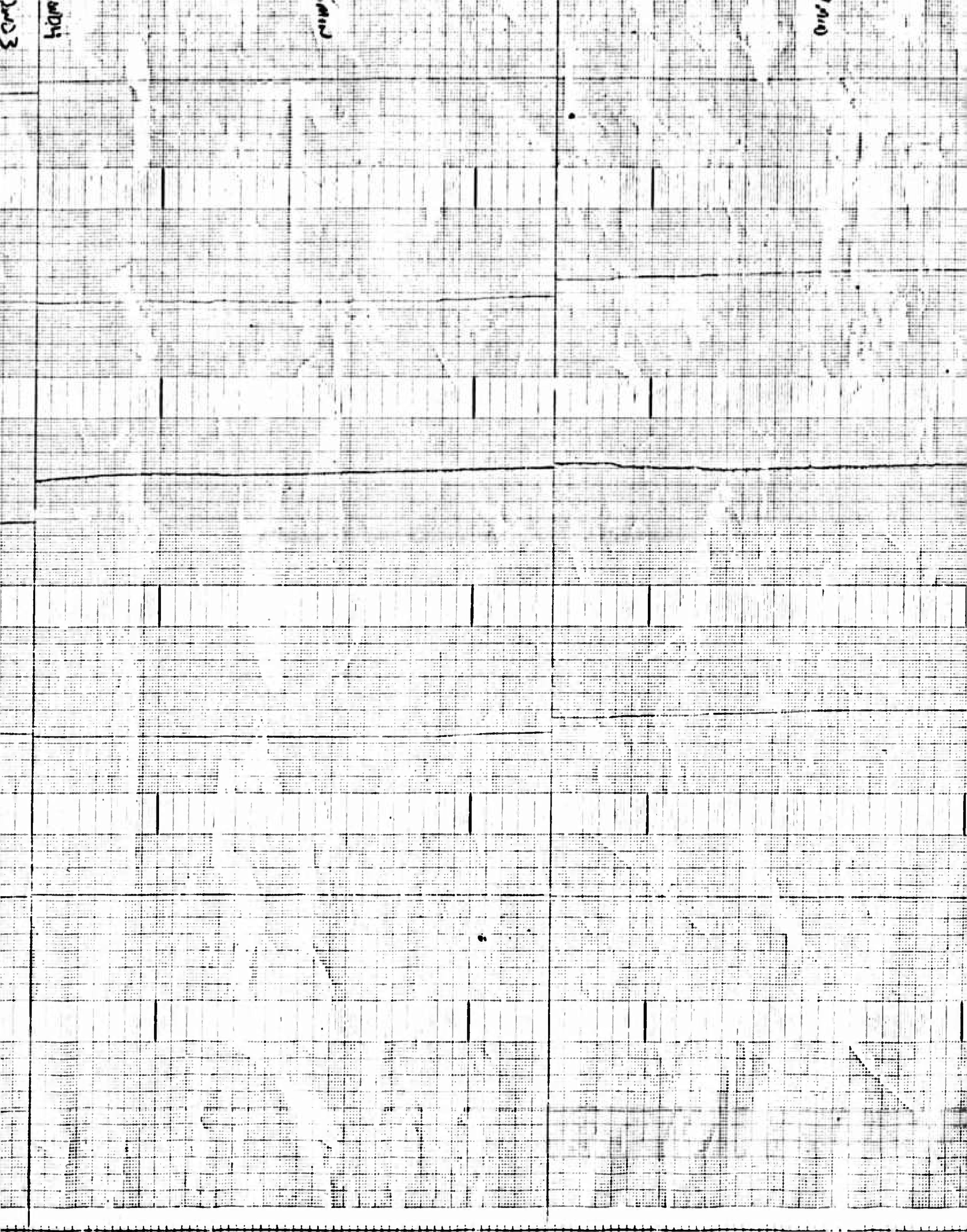


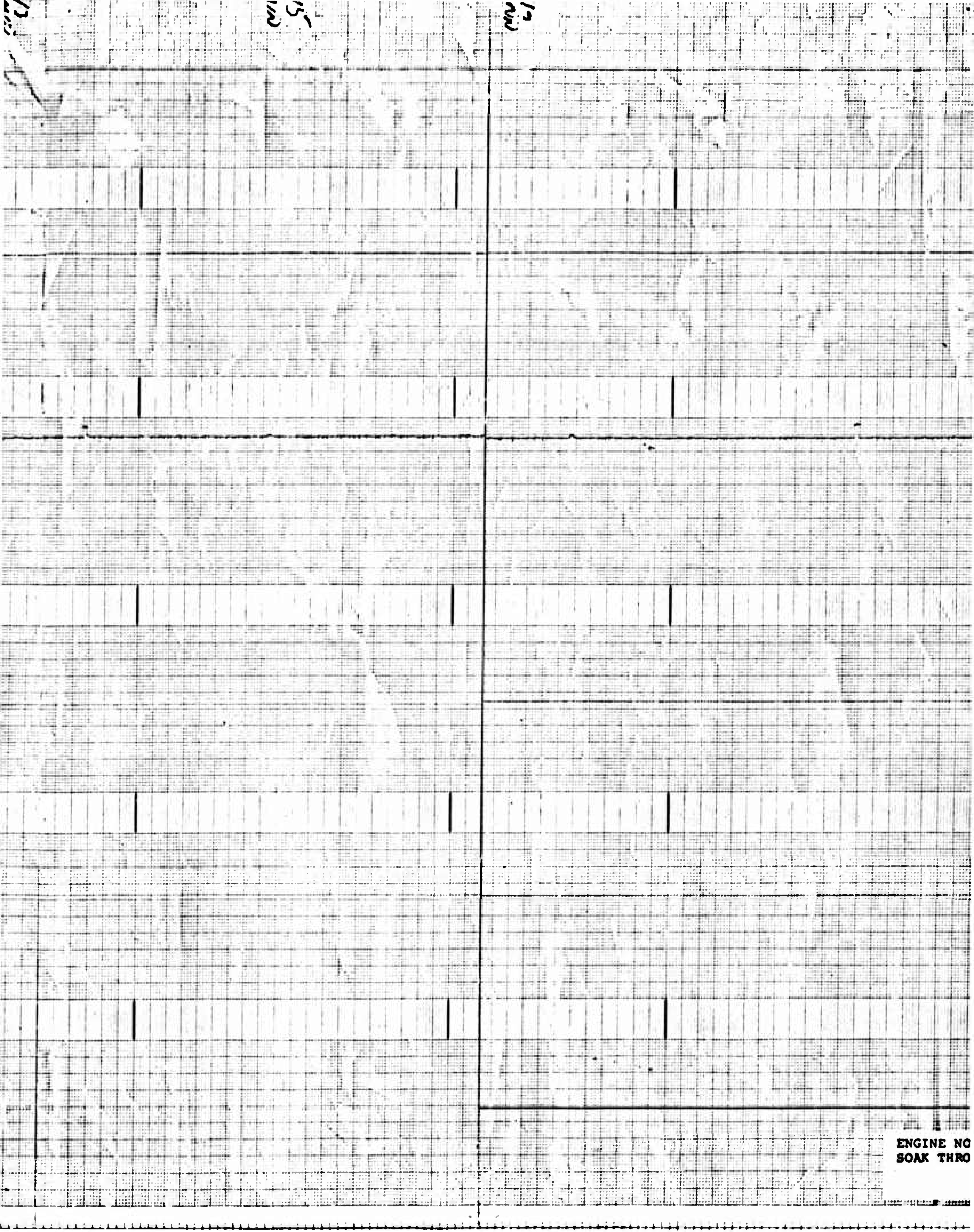
ENGINE NO. 1 IFRT, FROM COLD SOAK THROUGH DESIGN-POINT (TRACE NO.1)

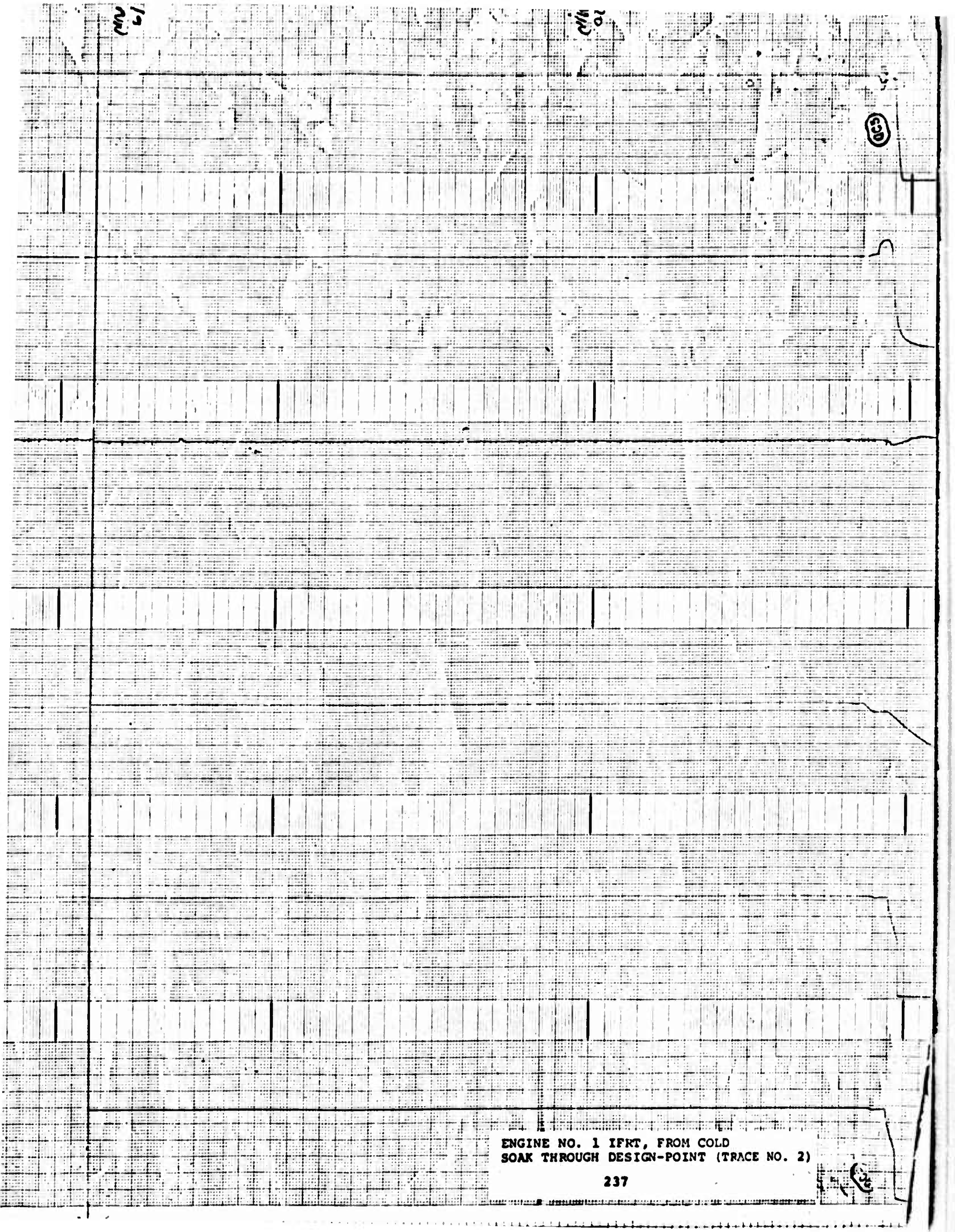

K RPM 25K
N_1
100 PSIA
P_x CONTROL PRESS. PSIA
0
+200°F
COMPR. INLET TEMP.
0
-50
100 PSIA
THRUST CAVITY PRESS.
0
200A
⑤ ALTERNATOR CURRENT
0
⑦
50V
⑥ ALTERNATOR VOLTS
0
⑧
50 ⑦ STARTER SQUIB VOLTS
0
10 ⑧ STARTER SQUIB AMPS
0
1 FRT #1
-65°F. COLD SOAK
4/7/73
12:15 PM




3 MIN




ENGINE NO
SOAK THRO



ENGINE NO. 1 IFRT, FROM COLD
SOAK THROUGH DESIGN-POINT (TRACE NO. 2)

FORM NO. P5330
150 BOOKS 4-71
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona Page No. 1 of

QUALIFICATION TEST LOG

E.W.O. No. 3209-410019-73-0210 | Date 3-30-73 | Test Cell or Station No. LACC-2

Assembly No. 3760300-1 | Model No. XJ401GA (OC) | Unit Serial No. IERT 2

Development Engineer D. CHRISTIANSEN | Technician STU - WHIT | Grp. Ldr. BENNETT

Test Type: TIME | AIR | START | TOTAL | Test Schedule | Modification

TIME START	TIME STOP				Event	O.C.
					CLEAN INLET CONTROL BOX P-101	
					INST ENG & HOOK UP REQ INSTRUMENTATION FOR COMBUSTOR / DIFFUSER GREEN RUN REF. T.I. 8014	
					WINDMILL RUN-IN, MIN FLOW 250PPH	
					INST 30 GAI PYRO - NO DELAY SET UP FOR WINDMILL START	
0831			1		L/O @ 9600 TO GOV SPD NOT GOV RUN TIME ON CONDITION 120 SEC	
	0836	04:26			TOTAL RUN TIME 266 SEC	
					REMOVED TO DEV ASSY	

SUMMARY: Total Running Time ______ hrs. ______ min. Ref. Data Page ______

Total Manual Starts ______

Total Automatic Starts ______ Engineering ______

FORM NO. PE830
150 BOOKS 6-72
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona

Page No. 1 of ____

QUALIFICATION TEST LOG

E.W.O. No. 3201-4100M-73-0200 Date 3-31-73 Test Cell or Station No. LACC-2

Assembly No. 3740300-1 Model No. XJ 401-GH-400 Unit Serial No. IFRT #2

Development Engineer W. E. WILLIAMS Technician STU-WHIT Grp. Ldr. BENNETT

Test Type ACCEPTANCE Test Schedule ATP 4030R REV G Modification

START TIME	STOP TIME	RUN MIN.	STARTS	TIME	REMARKS
					INSTALL ENG & HOOK UP REQ INSTRUMENTATION
					PER ATP 4030-R REV 6
					RUN-IN PER ¶ 4.1. A, B, C, MIN FLOW
					246 PPH, D, E.
					¶ 4.2.1. A, B,
1306	1307	:00:35 / :35	1		¶ 4.2.2. A, B, C, D, E, F, G, H,
					LOST SPD SIGNAL - ABORT
					FOUND BROKEN LEADS IN PCU - REPAIRED
					RE-RUN ¶ 4.2.2. A, B, C, D, E, F, G, H, I, J, K,
1422	1425	02:40 / 03:15	2		L, M, N, O, P, Q, R, S,
					REJECT ENG PER ENG'R INSTRUCTIONS

SUMMARY: Total Running Time ____ hrs. ____ min. Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____ Engineering ____

ORIGINAL

FORM NO. P5050
150 BOOKS 6-72
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona   Page No. 2 of ____

QUALIFICATION TEST LOG

E.W.O. No. 3709-4100A-73-0200	Date 4-1-73	Test Cell or Station No. AHCC-2
Assembly No. 3740300-1	Model No. XJ 401 GA-400	Unit Serial No. 1PRT #2 B40 1
Development Engineer W. E. WILLIAMS	Technician STU-WHIT	Grp. Ldr. BENNETT
Test Type ACCEPTANCE	Test Schedule ATP 4030R REV 6	Modification

START TIME	STOP TIME	RUN MIN.	START	TIME	REMARKS
		03:15	2		
					INST ENG & HOOK UP PER ATP 4030R REV 6
					CONTROL BOX S/N P-105, T2 SENSOR 641.
					RUN-IN PER P 4.1. A, B, C, MIN FLOW 248 PPH
					D, E.
					P 4.2.1 A, B.
1932			3		P 4.2.2. A, B, C, D, E, F, G, H, I, J, K, L, M, N,
	1935	02:40 5:55			O, P, Q, R, S.
1953			4		P 4.3. A, B, C, D, E, F, G, H, I, K, L,
	1954	1:20 7:15			RUN TIME 80 SEC.
					P 4.3. L, M, N, O.
					P 6.1. A, B, C,
					4-2-73 SAN TAN
					INSTALLED ENGINE ON CENTRIFUGE PER
1440	1441				P 3.2.3.1 (a) OF QT-8090A. RAN
					61-65 RPM FOR 15 SECONDS.
					REPOSITIONED ENGINE PER P 3.2.3.1 (b) OF QT8090A
1517	1518				RAN 61-64 RPM FOR 15 SECONDS.
					REPOSITIONED ENGINE PER P 3.2.3.1 (c) OF
1616	1617				QT-8090A. RAN 61-64 RPM FOR 15 SECONDS.

FT 170

SUMMARY: Total Running Time ____ hrs. ____ min.   Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____
Engineering W. E. Williams

ORIGINAL

FORM NO. P8330
150 BOOKS 6-72
MESSENGER GRAPHICS

AiResearch Manufacturing Company of Arizona   Page No. 3 of ____

QUALIFICATION TEST LOG

E.W.O. No. 3204-41044-73-020 | Date 4-4-73 | Test Cell or Station No. LHCC-2

Assembly No. 3740300-1 | Model No. XT-401-6A-400 | Unit Serial No. IFRT # 2

Development Engineer W. R. WILLIAMS | Technician STU-WHIT | Grp. Ldr. BENNETT

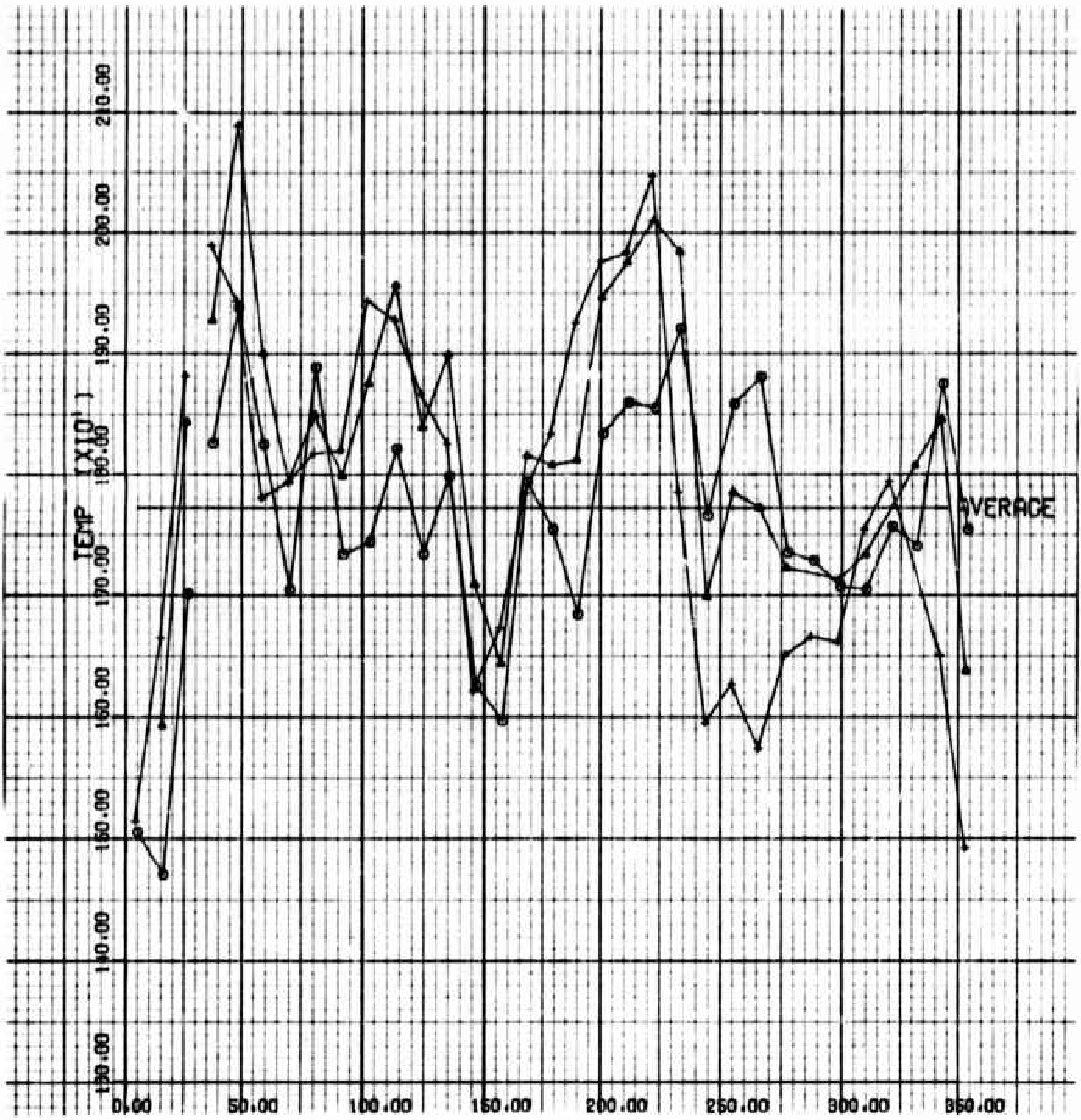
Test Type IFRT | Test Schedule QT 4090 A | Modification

START TIME	STOP TIME	RUN MIN.	STARTS	TIME	REMARKS
		07:15	4		
					INSTALL ENG + HOOK UP PER QT 4090A
					P 3.2.31 A, B, C, D, E, F, G.
0738	0804	26:14 33:29	5		P 3.2.3.2. A, B, C, D, E, F, G, H, I, J, K, L, M, N, O
					RUN TIME 26 MIN, 14 SEC
					REMOVE TO DEV ASSY

RCT
FT 170

SUMMARY: Total Running Time ____ hrs. ____ min.   Ref. Data Page ____
Total Manual Starts ____
Total Automatic Starts ____   Engineering ____

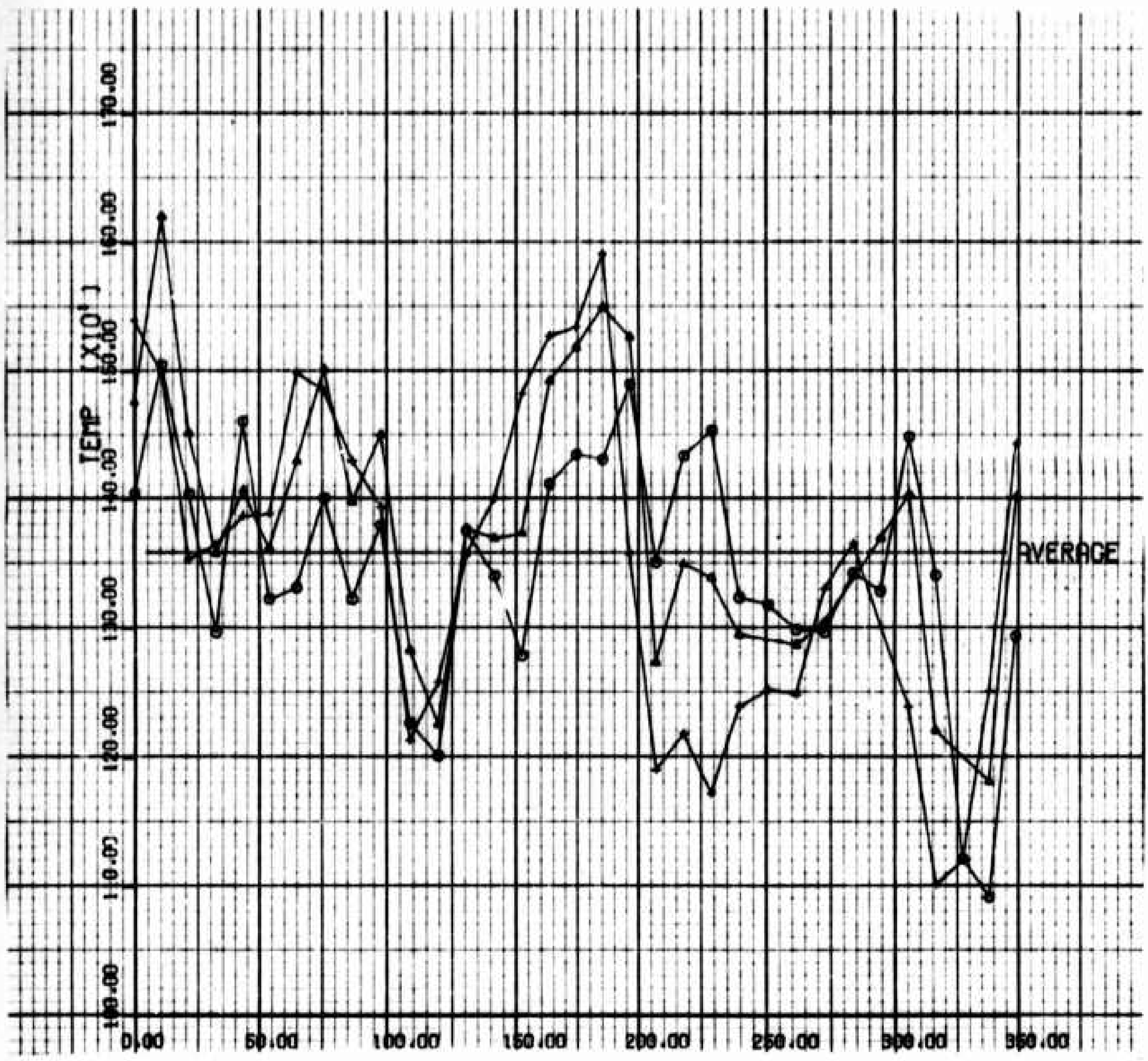
ORIGINAL



ANGLE-DEGREES
MEASURED CLOCKWISE FROM TOP LOOKING AFT

TURBINE INLET TEMPERATURE (T_4) COMPUTED DATA
O = r (3.6 INCHES) Δ = r (4.0 INCHES) + = r (4.4 INCHES)

GREEN RUN ON IFRT ENGINE NO. 2 (3-30-73)
TEMPERATURE SPREAD FACTOR (TSF) = 0.23



ANGLE-DEGREES
MEASURED CLOCKWISE FROM TOP LOOKING AFT

TURBINE DISCHARGE TEMPERATURE (T_5) MEASURED DATA
0 = r (3.6 INCHES) Δ = r (4.0 INCHES) + = r (4.4 INCHES)

GREEN RUN ON IFRT ENGINE NO. 2 (3-30-73)
TEMPERATURE SPREAD FACTOR (TSF) = 0.23

MODEL X -GA-400

SERIAL NO. 1FRT 2 RUN TIME 4 MINUTES
DATE 4-1-73 TIME OF DAY 1835

?? 8130
Rev. 3

Barometric pressure 28.55 In. HgA

Start time 6 Sec. At Altitude 20,400 Ft

T_{wet} 55 °F

Max. $T_t7.0$ 1657 °F

T_{dry} 68 °F

Engine weight 154.5 Lbs.

Fuel specific gravity .79

Average exhaust nozzle I.D. 5929 In.

Speed signal actuation point (alternator load) 30,200 rpm

Engine C.G. station 142.8.

Total running time 4:00 min:sec.

Symbol	Parameter	Units	Perf. Rating (b) (3.8 KW OUTPUT) Measured	Perf. Rating (b) (3.8 KW OUTPUT) Referred Data	Perf. Rating (a) ZERO LOAD OUTPUT Measured	Perf. Rating (a) ZERO LOAD OUTPUT Referred Data		
$T_t1.0$	Inlet temperature	°F	168.6	169	168.4	169		
F_N	Net thrust	Lbs		616.0		603		
N	Speed	Rpm	35856	35866	35919	35919		
F_{meas}	Thrust	Lbs	401		390			
$P_t1.2$	Bellmouth total pressure	psig	8.48		8.48			
$P_s1.2$	Bellmouth static pressure	psig	7.00		6.94			
SFC	Specific Fuel Consumption	LB/HR/LB		1.627		1.616		
W_a	Airflow	LB/Sec		13.0		12.8		
$T_t7.0$	Turbine discharge temperature	°F	1580	1580	1539	1539		
A	Output current	Amps	127.8					
V	Output voltage	VDC	29.95					
-	Electrical load	kw		3.8				
W_f	Fuel flow	PPH	964	994	928	974		
Vib.	Engine vibration	Mils	0.75		0.9			
$P_{t1.2}-P_{s8}$	Ram ΔP	in. Hg	17.22	17.22	17.2	17.2		
M	Mach Number	-	.85	0.85	.85	0.85		
Alt.	Altitude	Ft.	1317	S.L.	1305	S.L.		

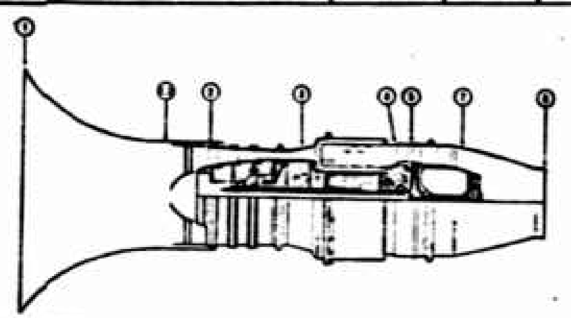
LIMITS:

Fuel inlet pressure: 41-65 psia (sea level)
Operating time: Maximum of 4.0 minutes
Electrical load: 3.8 kw minimum 4.0 kw maximum
Vibration: 3.0 mils double amplitude maximum steady state

Start Time 18 Seconds max.
Speed signal actuating point: 28,700 rpm to 30,900 rpm.

PERFORMANCE RATING AT SEA-LEVEL ALTITUDE, 90°F AMBIENT CONDITION

	Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	SFC lb/hr/lb of Thrust (Max)	Measured Turbine Discharge Gas Temp. (Max) °F	Measured Turbine Discharge Gas Temp. (Max) °C	Airflow Pounds Per Second ±3.0%	Electrical Output kw
(a)	Maximum	0.85	599	37,060	1.679	1579	859	13.5	Zero
(b)	Maximum	0.85	600	36,960	1.687	1582	861	13.5	3.8



	SIGNATURE	DATE
TECHNICIAN	[signature]	4-1-73
SUPERVISOR	[signature]	4-1-73
QUALITY CONTROL	[signature]	4-1-73
GOVERNMENT	R.P.B. [signature]	4-1-73
ENGINEER	[signature]	4-1-73

FORM NO. P0177A

LABORATORY DATA SHEET

Date 4-3-73　　Page ___ of ___ Pages

Test Purpose 10 HR HOT SOAK @ +160°F

Bar. ______ "Hg Lab. Temp. ______ F.

Test Personnel WHITTEN

Dev. Engr. WILLIAMS

EWO No. 3209-410019-73-0200

Part No. IFRT #2

Lab. Unit No. —　　S/N 2

Station No. LACC-2

INSTR. S/N		Row 2 #12		#16											
TIME HOUR	1	CELL AMB 2	3	ENG. SKIN 4	5	HRS. COMPLETED 6	7	8	9	10	11	12	13	14	REMARKS
1 2045		164		160		0									
2 2145		163		161		1.0									
3 2245	OC3	163		161		2.0									
4 2345		164		162		3.0									
5 0045		162		162		4.0									
6 0145		160		160		5.0									
7 0245		161		161		6.0									
8 0345		161		161		7.0									
9 0445		162		162		8.0									
10 0545		161		162		9.0									
11 0645		161		161		10.0	OC17								
12 0710		160		161											
13															
14															
15															
16															
17															
18															
19															
20															

HIGH TEMPERATURE START AND SEA-LEVEL ENDURANCE TEST INITIAL FLIGHT RATING TEST PROGRAM

DS-8145 Rev. 1 2-9-73

MODEL XJ401-GA-400

SERIAL NO. IFRT 2 RUN TIME 26 MIN.

DATE 4 APR 73 TIME OF DAY 0738

Barometric pressure 28.82 in. Hg A

T_{wet} 49 °F

T_{dry} 60 °F

Fuel specific gravity .775

Speed signal actuation point 30,200 rpm

Start time 6 Sec.

Max. $T_t7.0$ 1521 °F

Engine weight 154.5 Lbs.

Average Exhaust Nozzle I.D. 5.929 In.

Engine C.G. Station 142.8

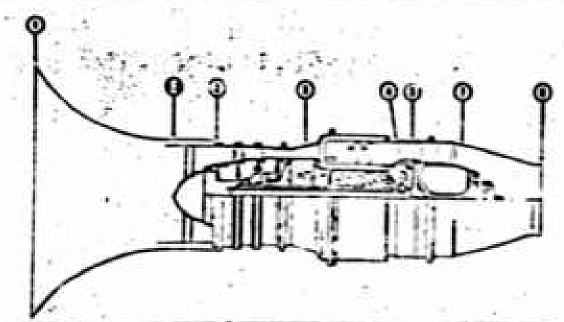
LIMITS:

Fuel inlet pressure	29.5-40.0 psia (20,000 ft) 41-46 psia (Sea Level)
Operating time	Min. 16 min; Max. 30 min.
Electrical load	3.8 kw min. 4.0 kw max.
Start Time:	18 Seconds Max.
Speed signal actuation point	28,700 to 30,900 rpm

PERFORMANCE RATING AT SEA-LEVEL ALTITUDE, 90°F AMBIENT CONDITION

Rating	Mach Number	Net Thrust Pounds (Min)	Engine Rotor RPM (Max)	SFC lb/hr/lb of Thrust (Max)	Measured Gas Temp. (Max) °F	Measured Gas Temp. (Max) °C	Airflow Pounds Per Second ±3.0%	Electrical Output kw
Maximum	0.85	600	36,950	1.687	1582	861	13.5	3.8

Symbol	Parameter	Units	Starting Condition Meas.	Starting Condition Referred Data	~~Beginning~~ of Endurance Meas.	~~Beginning~~ of Endurance Referred Data	Minutes of Endurance Meas.	Minutes of Endurance Referred Data	Minutes of Operation Meas.	Minutes of Operation Referred Data
$T_t1.0$	Inlet temperature	°F	62	60	173.6	169.4	168.8	169.4	168.3	169.4
-	Net thrust	Lbs		159		572		578		578
N	Speed	Rpm	31291	31268	36024	36087	36097	36072	36108	36083
F_{meas}	Thrust	Lbs	124		357		373		375	
$P_t1.2$	Bellmouth total pressure	psig	2.18		8.97		8.61		8.61	
$P_s1.2$	Bellmouth static pressure	psig	1.58		7.40		7.04		7.02	
-	SFC	Lb/Hr/Lb		1.645		1.596		1.602		1.616
-	Airflow	Lb/Sec		5.16		12.94		12.97		13.65
$T_t7.0$	Turbine discharge temperature	°F	894	899	1402	1405	1419	1418	1406	1406
A	Output current	Amps	115		119		122		122	
V	Output voltage	VDC	27		29		28.5		28.6	
-	Electrical load	kw		3.1		3.5		3.5		3.5
W_f	Fuel flow	PPH	265	260	887	913	893	926	901	934
Vib.	Engine vibration	Mils	0.9		0.7		0.6		0.7	
$P_t1.2-P_s8$	Ram ΔP	in. Hg	4.29	4.29	18.3	17.4	17.5	17.4	17.5	17.4
M	Mach number	M	.65	0.6	.87	0.85	.855	0.85	.855	0.85
Alt	Altitude	Feet	20,342	20,000	1159	S.L.	1171	S.L.	1147	S.L.



	SIGNATURE	DATE
TECHNICIAN	[illegible]	4-4-73
SUPERVISOR	[illegible]	4/4/73
QUALITY CONTROL	[illegible]	4-4-73
GOVERNMENT	A.P. [illegible]	4 Apr 73
ENGINEERING	[illegible]	4/5/73

PRESET

DATA SHEET

FLUID: MIL-F-7024A, TYPE II AT 100° ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2274-3
DATE 3-28-73
STAND NO. C120 #3
Pump S/N 2273-3

3.2 BYPASS VALVE SETTING:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	ΔP_{1-2} (PSI) REQD	ΔP_{1-2} (PSI) ACT.	
1	BYPASS VALVE SET	36000	80	69/71	70	SHIM (S-8154-105) UNDER SPRING TO OBTAIN T.P.1.
2	BYPASS VALVE CHECK	28800	80	RECORD	69	

3.3 METERING VALVE SETTING:

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH)	
3	SLOPE SETTING	36000	80	RECORD: 1020	SET SLOPE ADJUST. TO OBTAIN T.P. 5 VALUE OF 590 ±10 PPH
4		36000	40	RECORD: 438	
5	T.P.3 MINUS T.P.4			582	

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH) REQD	FUEL FLOW (PPH) ACT.	
6	LEVEL ADJUST	36000	80	1010±10	1020	SHIM (S-8154-409) SCREW ADJUST.
7	MINIMUM FLOW STOP	21600	15	260 ±3	263	

	Function	Speed (RPM)	Fuel Flow (PPH)	P_3 (PSIA) Reqd	P_3 (PSIA) Act	
8	Minimum Flow [illegible]	21600	270	32 ±2	32.6	

FINAL

DATA SHEET

TEST FLUID: 7024A, TYPE II @ 100 ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2274-3
DATE 3-28-73
TEST STAND #3
Pump S/N 2273-3

3.5 HYSTERESIS & LINEARITY CHECK:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	P_1 (PSIG)	ΔP_{1-2} (PSI)	FUEL FLOW (PPH) MIN.	ACT.	MAX.
	METERING VALVE:							
8	LINEARITY CHECK	36000	40				438	
9			60				725	
10			80			1000	1020	1020
11			100				1260	
12			120				1370	
13			80				1020	
14			40				439	
15	HYSTERESIS: DIFF. BETWEEN T.P. 10 & 13 SHALL NOT EXCEED 4 PPH.							
16	SLOPE CHECK: DIFF. BETWEEN T.P. 8 & 10 SHALL BE					580	582	600
17	MINIMUM FLOW STOP	21600	15			257	263	263
18	Minimum Flow Boost [illegible]	21600	32.6				270	
19	Maximum Flow Stop	36000	100			945	950	955

TI-3740425

342

PRESET

DATA SHEET POST IFRT FINDINGS

FLUID: MIL-F-7024A, TYPE II AT 100° ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2274-3
DATE 4/5/73
STAND NO. #3
Pump S/N 2273-3

3.2 BYPASS VALVE SETTING:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	ΔP_{1-2} (PSI) REQD	ΔP_{1-2} (PSI) ACT.	
1	BYPASS VALVE SET	36000	80	69/71	70	SHIM (S-8154-105) UNDER SPRING TO OBTAIN T.P.1.
2	BYPASS VALVE CHECK	28800	80	RECORD	67	

3.3 METERING VALVE SETTING:

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH)	
3	SLOPE SETTING	36000	80	RECORD: 1000	
4		36000	40	RECORD: 440	SET SLOPE ADJUST. TO OBTAIN T.P. 5 VALUE OF 590 ±10 PPH
5	T.P.3 MINUS T.P.4			560	

	FUNCTION	SPEED (RPM)	P_3 (PSIA)	FUEL FLOW (PPH) REQD	FUEL FLOW (PPH) ACT.	
6	LEVEL ADJUST	36000	80	1010±10	1000	SHIM (S-8154-409) SCREW ADJUST.
7	MINIMUM FLOW STOP	21600	15	260 ±3	262	

	FUNCTION	SPEED (RPM)	FUEL FLOW (PPH)	P_3 (PSIA) REQ.	P_3 (PSIA) ACT	
8	[illegible]	21600	270	32±2	32	

POST IFRT FINDINGS
FINAL

DATA SHEET

TEST FLUID: 7024A, TYPE II @ 100 ±15°F
P_o = 35 ±1 PSIG

P/N 3740425-1
S/N 2274-3
DATE 4/5/73
TEST STAND #3
Pump S/N 2273-3

3.5 HYSTERESIS & LINEARITY CHECK:

TEST PT.	FUNCTION	SPEED (RPM)	P_3 (PSIA)	P_2 (PSIG)	ΔP_{1-2} (PSI)	FUEL FLOW (PPH) MIN.	ACT.	MAX.
	METERING VALVE:							
8	LINEARITY CHECK	36000	40				440	
9			60				720	
10			80			1000	1000	1020
11			100				1220	
12			120				1400	
13			80				1004	
14			40				442	
15	HYSTERESIS: DIFF. BETWEEN T.P. 10 & 13 SHALL NOT EXCEED 4 PPH.							
16	SLOPE CHECK: DIFF. BETWEEN T.P. 8 & 10 SHALL BE					580	560	600
17	MINIMUM FLOW STOP	21600	15			257	262	263
18	Minimum Flow Breakaway	21600	32.0				270	
19	Minimum Flow Stop	36000	100			945	955	955

Removed MAX Flow Stop, To check All points To T.I. [illegible].

DS-3740427, Rev. 1
11-21-72

DATA SHEET

TEST FLUID: DRY, FILTERED AIR @ 80° ±40°F

TEST STAND #3
P/N 3740427-1
S/N 011
DATE 3-22-73

① PAR. 3.2 - CONTINUITY CHECK ☑

COIL RESISTANCE: 190 OHMS
APPROXIMATELY 180-216

TEST POINT	T.I. PARAGRAPH	CALIBRATION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA)		
					MIN	ACT	MAX
②	3.3.3	SET NOZZLE TO OBTAIN	90	+10	82.6	82.6	83.6
③	3.3.3	SLOPE CHECK POINT	90	+30	68.0	69.9	70.0

④ PAR. 3.3.3 - FINAL ORIFICE (d_o) DIAMETER: .0292 INCH.

TEST POINT	T.I. PARAGRAPH	FUNCTION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA)		
					MIN	ACT	MAX
5	3.4	Linearity & hysteresis	90	-10	-	90	-
6				0	-	87.5	-
7				10	82.6	82.6	83.6
8				20	-	76.6	-
9				30	68.0	69.9	70.0
10				40	-	62.0	-
11				50	~~X~~	53.0	55.5
12				60	-	46.4	-
13				50	~~X~~	53.0	55.5
14				40	-	62.2	-
15				30	68.0	69.9	70.0
16				20	-	77.0	-
17				10	82.6	82.9	84.6
18				0	-	87.5	-
19				-10	-	90.5	-

TECH [signature] FT-308
Q.C. ____________

DS-3740427, Rev. 1
11-21-72

POST IFRT FINDINGS

DATA SHEET

TEST STAND #3
P/N 3740427-1
S/N 011
DATE 4/5/73

TEST FLUID: DRY, FILTERED AIR @ 80° ±40°F

① PAR. 3.2 - CONTINUITY CHECK ☑ COIL RESISTANCE: 190 OHMS
APPROXIMATELY 180-216

TEST POINT	T.I. PARAGRAPH	CALIBRATION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA) MIN	ACT	MAX
②	3.3.3	SET NOZZLE TO OBTAIN	90	+10	82.6	83.2	83.6
③	3.3.3	SLOPE CHECK POINT	90	+30	68.0	69.5	70.0

④ PAR. 3.3.3 - FINAL ORIFICE (d_o) DIAMETER: .0292 INCH.

TEST POINT	T.I. PARAGRAPH	FUNCTION	P_1 (PSIA) ±0.2	INPUT CURRENT (MA)	P_x (PSIA) MIN	ACT	MAX
5	3.4	Linearity & hysteresis	90	-10	-	89	-
6				0	-	86.5	-
7				10	82.6	83.2	83.6
8				20	-	76.5	-
9				30	68.0	69.5	70.0
10				40	-	62	-
11				50	X	52	55.5
12				60	-	46.5	-
13				50	X	51.5	55.5
14				40	-	61	-
15				30	68.0	69.5	70.0
16				20	-	76	-
17				10	82.6	82.6	84.6
18				0	-	86.5	-
19				-10	-	89	-

TECH Stein FT 302
Q.C. ____

1A133-1

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

OIL & FUEL ANALYSIS 14275

MATERIALS ENGINEERING

APR 12 1973

Requestor Wade Williams Dept. 93-1701
Copies To R. D. Miller 93-15H

Customer
Engine Serial No. IFRT 2
Operating Hours
Sample Origin
Charge No. 3209-41001-73-0100
Date Required 4-4-73

Manufacturer
Date 4-1-73

☐ B. P. Distillation

IBP ____ °F
5% ____
10% ____
20% ____
30% ____
40% ____
50% ____ % @ 400°F
60% ____
70% ____
80% ____
90% ____
95% ____
E.P. ____
% Distilled ____

☐ Flash Point

COC ____ °F

☐ T.A.N. ____

☒ L.H.V.

15,570 Btu/lb.

☐ Other

☒ Specific Gravity

51.1° API @ 60°F

Sp.Gr. 0.775 @ 60°F

☐ Reid Vap. Press. ____ psi

☐ Viscosity

cs.	@ °F
	77
	100
	210

Analyst Jim Moore

FA1334-1

AIRESEARCH MANUFACTURING COMPANY
A DIVISION OF THE GARRETT CORPORATION
PHOENIX, ARIZONA

OIL & FUEL ANALYSIS 14,374

MATERIALS ENGINEERING

APR 12 1973

Requestor W. Williams Dept. 93-171 Customer
Copies To Engine Serial No. HET 2
Operating Hours
Sample Origin
Charge No. 3269-316019-93-0166
Manufacturer Date Required 4-4-73
Date 4-4-73

☐ B. P. Distillation

IBP °F
5%
10%
20%
30%
40%
50% % @ 400°F
60%
70%
80%
90%
95%
E.P.
% Distilled

☐ Flash Point

COC °F

☐ T.A.N.

~~☐ B.H.V.~~

☐ Other

☒ Specific Gravity

51.1° API @ 60°F

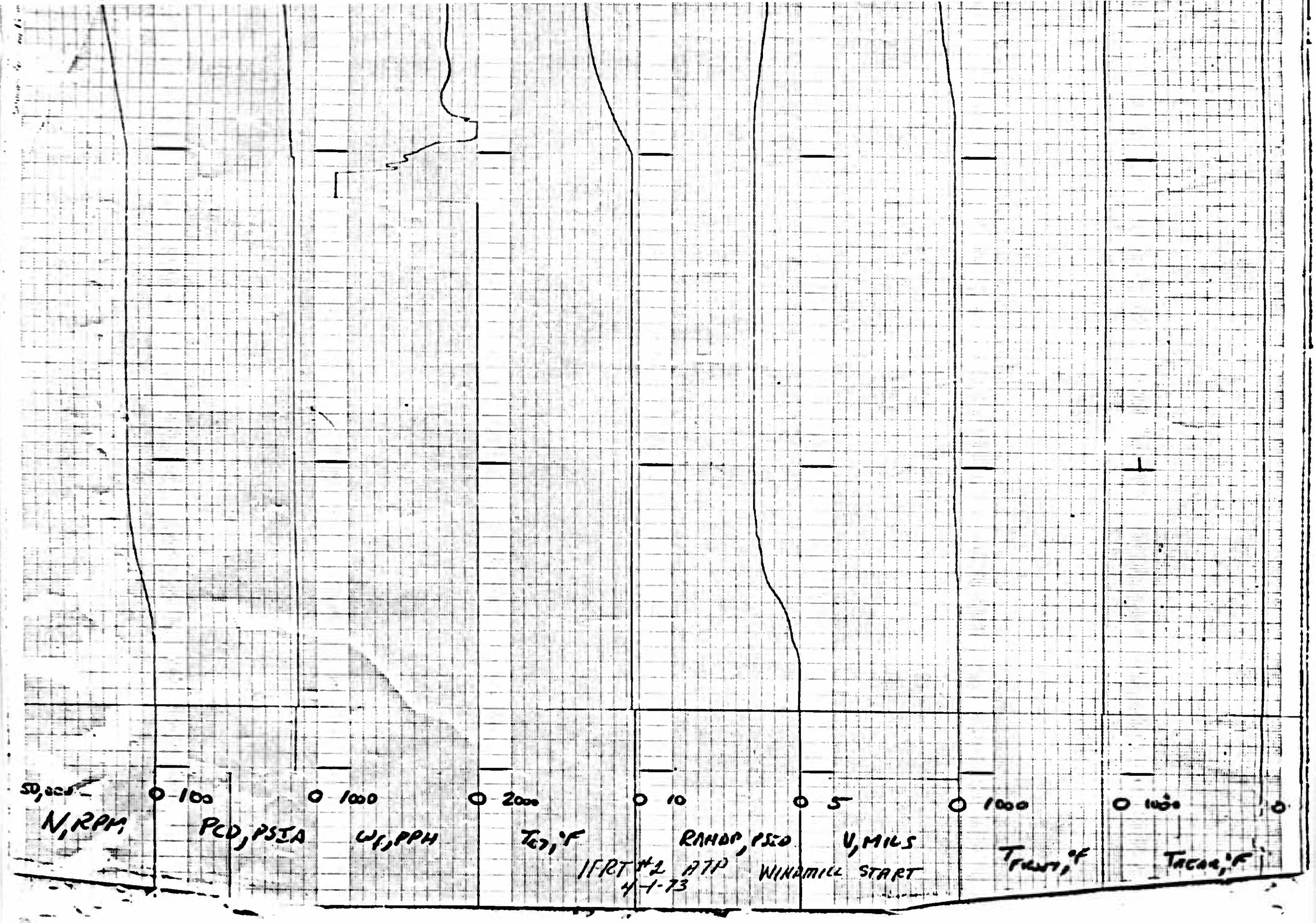
Sp.Gr. 0.775 @ 60°F

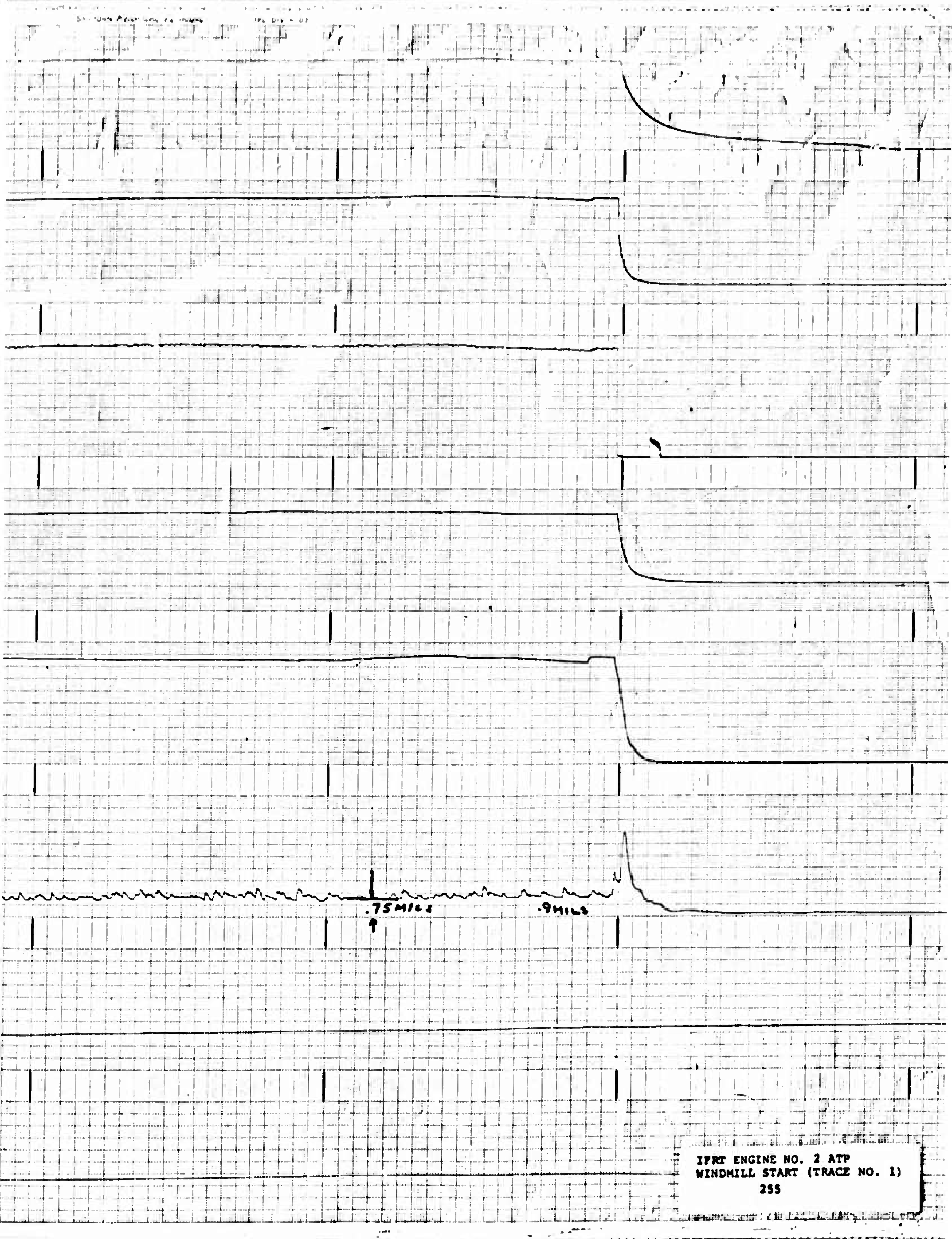
☐ Reid Vap. Press. psi

☐ Viscosity

cs.	@ °F
	77
	100
	210

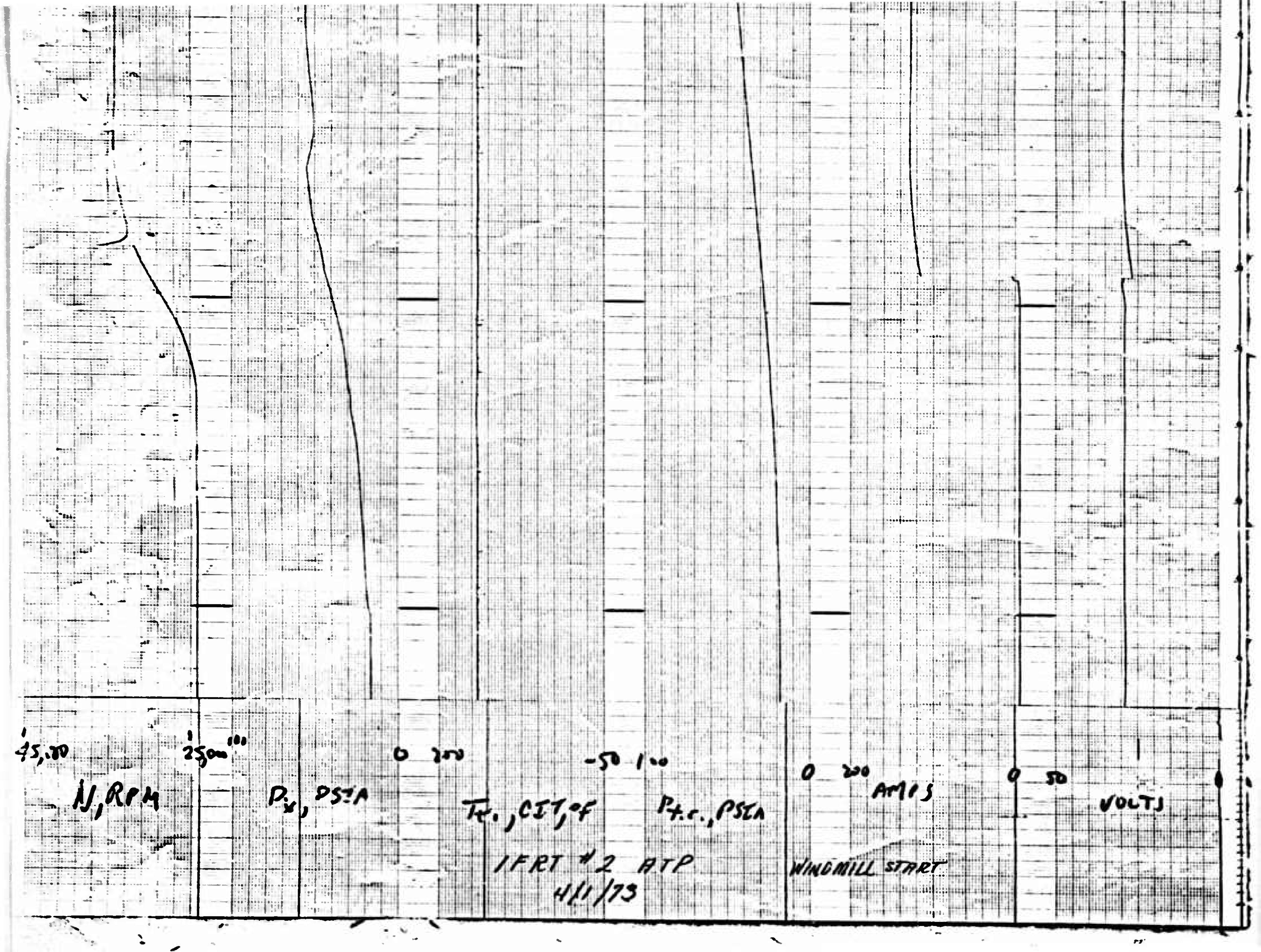
Analyst Jerry Moore

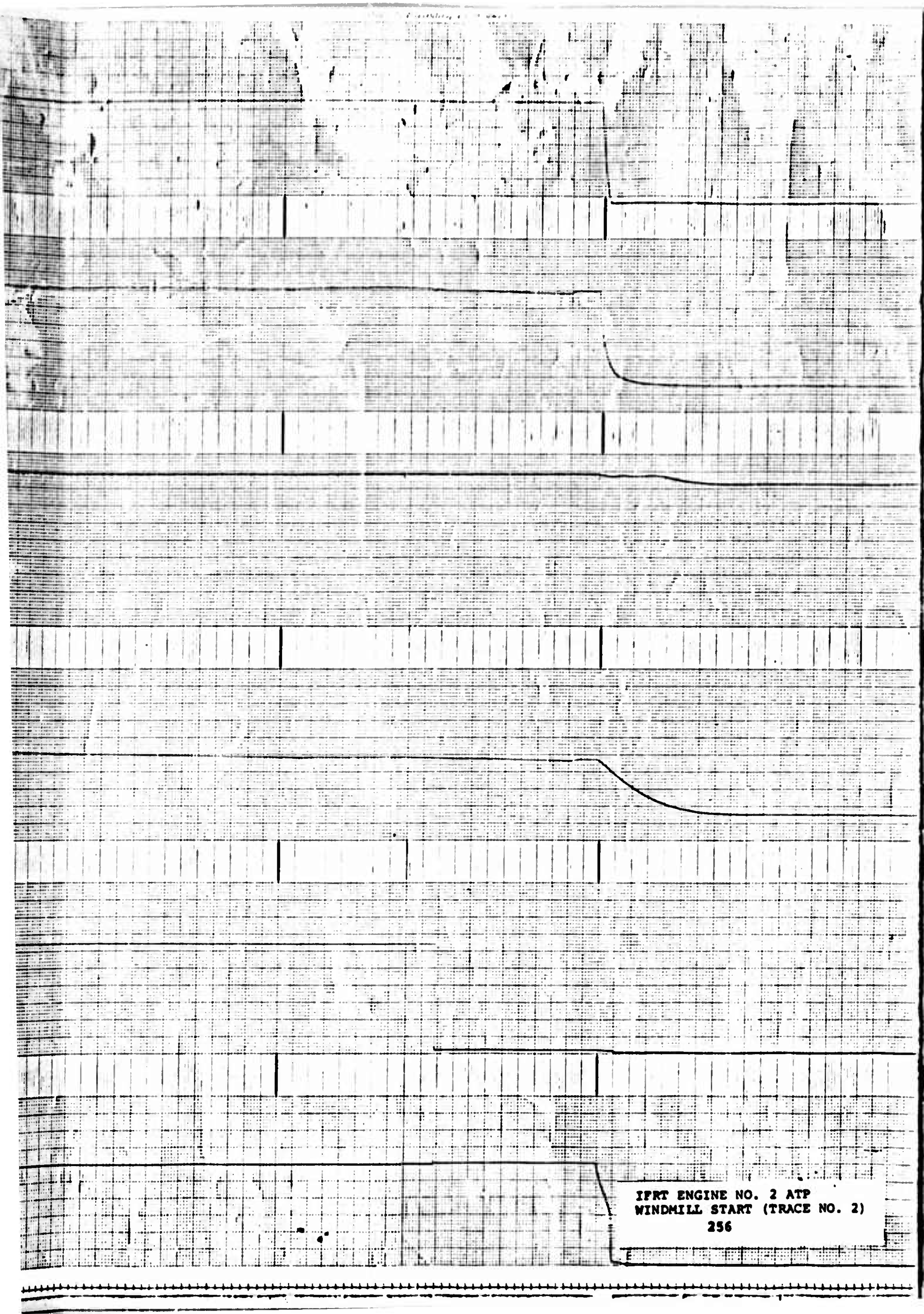

50,000
N, RPM
0 100
PCD, PSIA
0 1000
W, PPH
0 2000
T_{C7}, °F
0 10
RAHOP, PSID
0 5
V, MILS
0 1000
T_{FRONT}, °F
0 1000
T_{REAR}, °F
0
IFRT #2 ATP WINDMILL START
4-1-73



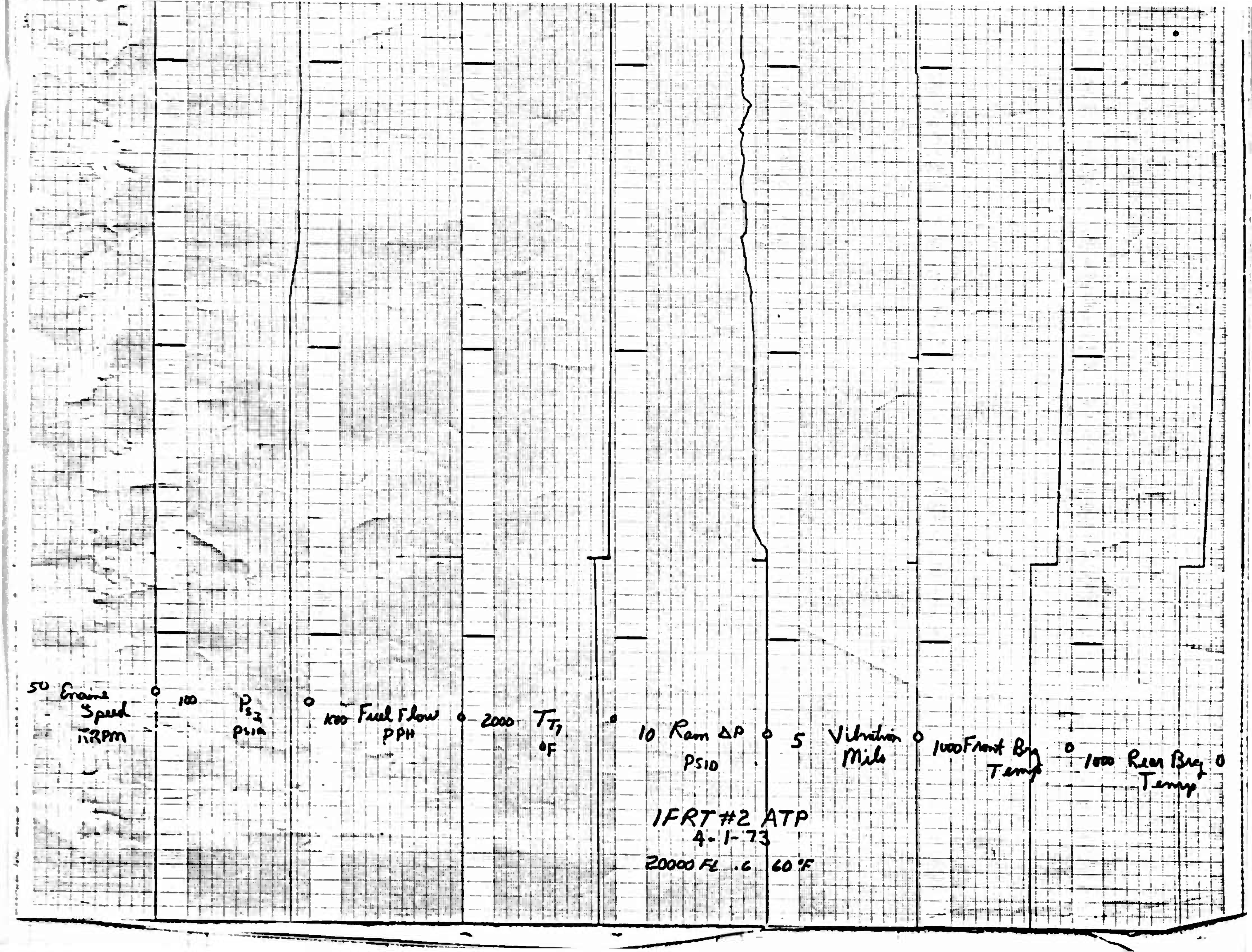
IFRT ENGINE NO. 2 ATP
WINDMILL START (TRACE NO. 1)

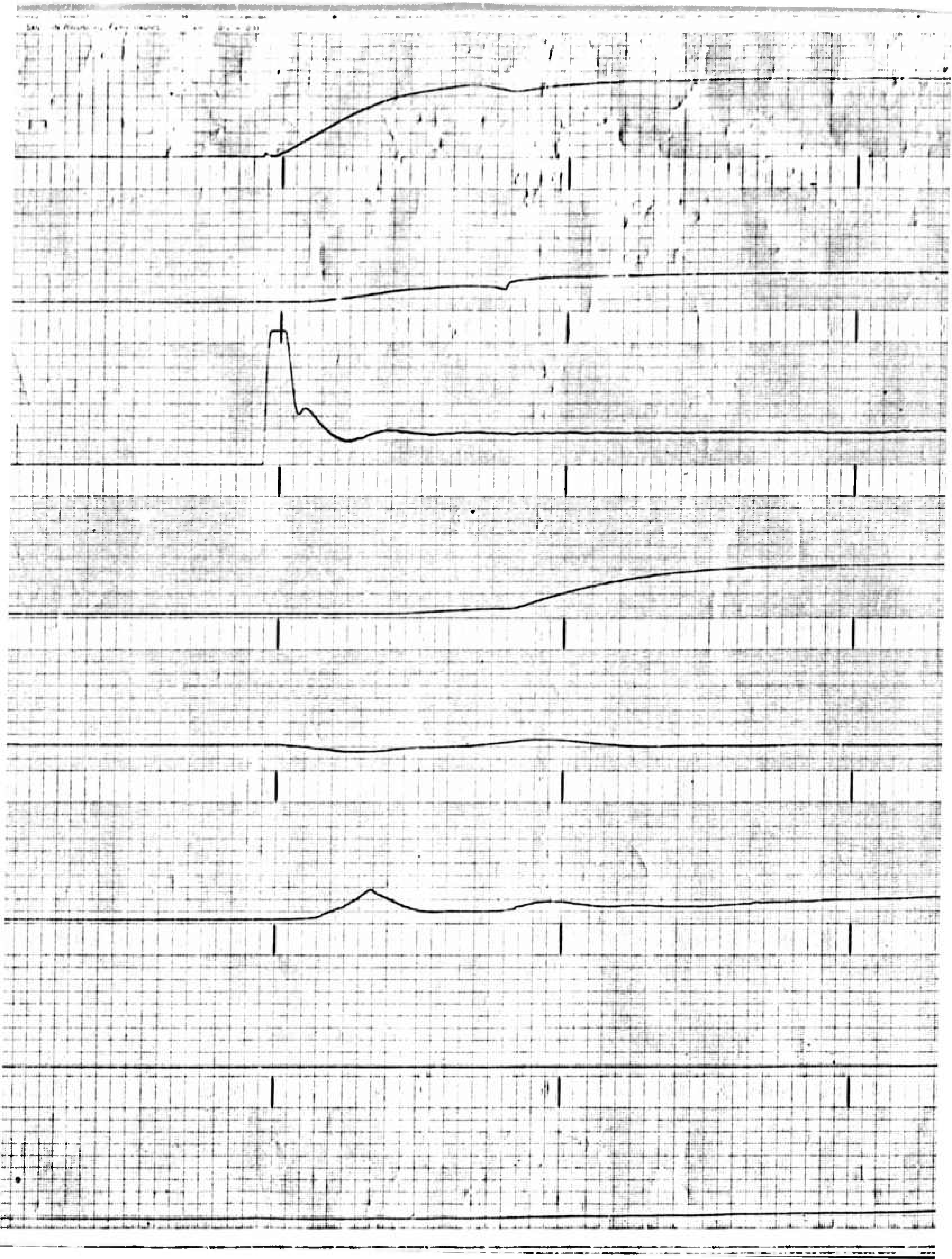
255

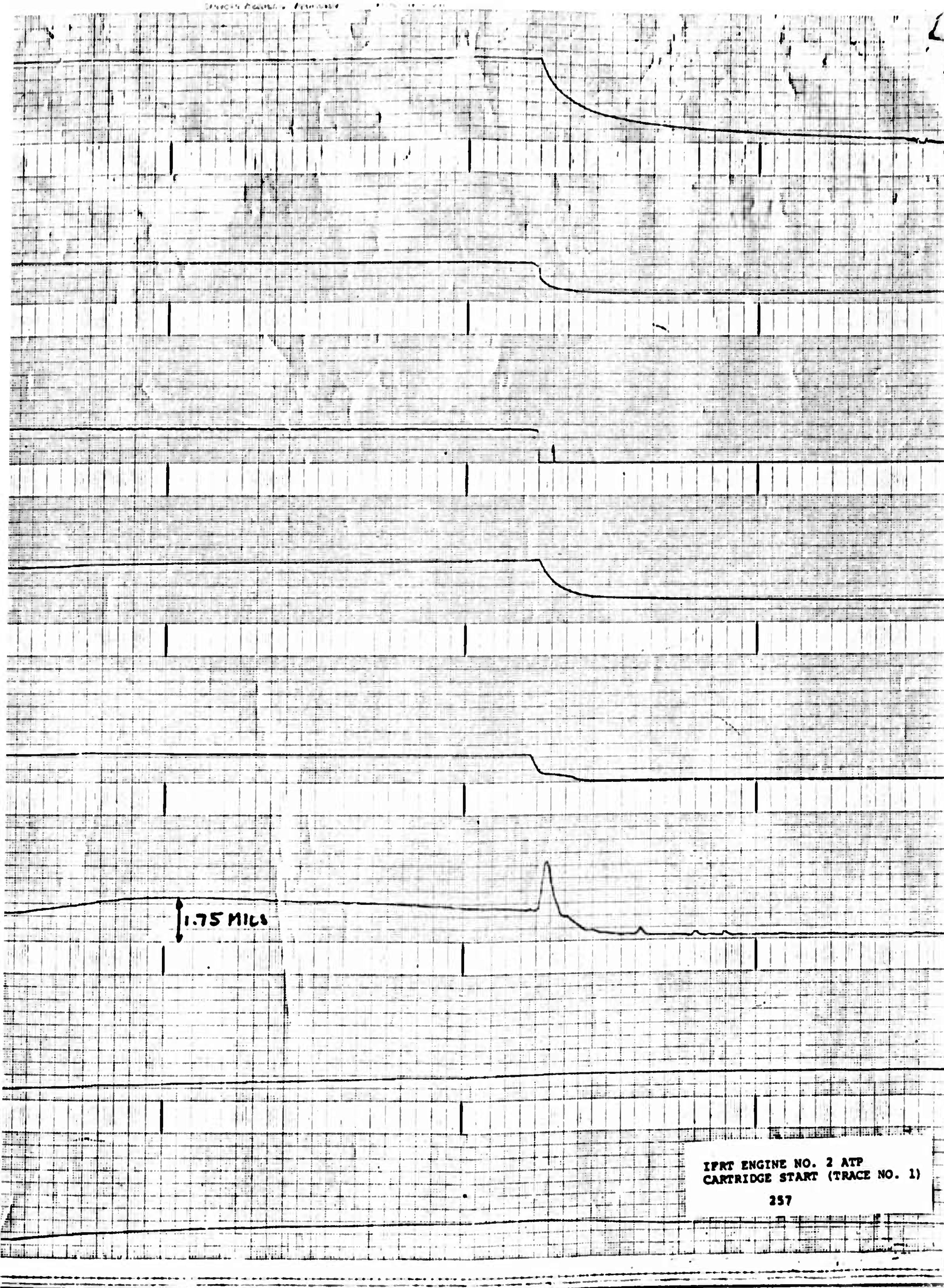

45,000
25,000
100
N, RPM
P, PSIA
0 200
T, CIT, °F
-50 100
P, PSIA
0 200
AMPS
0 50
VOLTS
IFRT #2 ATP
4/1/73
WINDMILL START



256

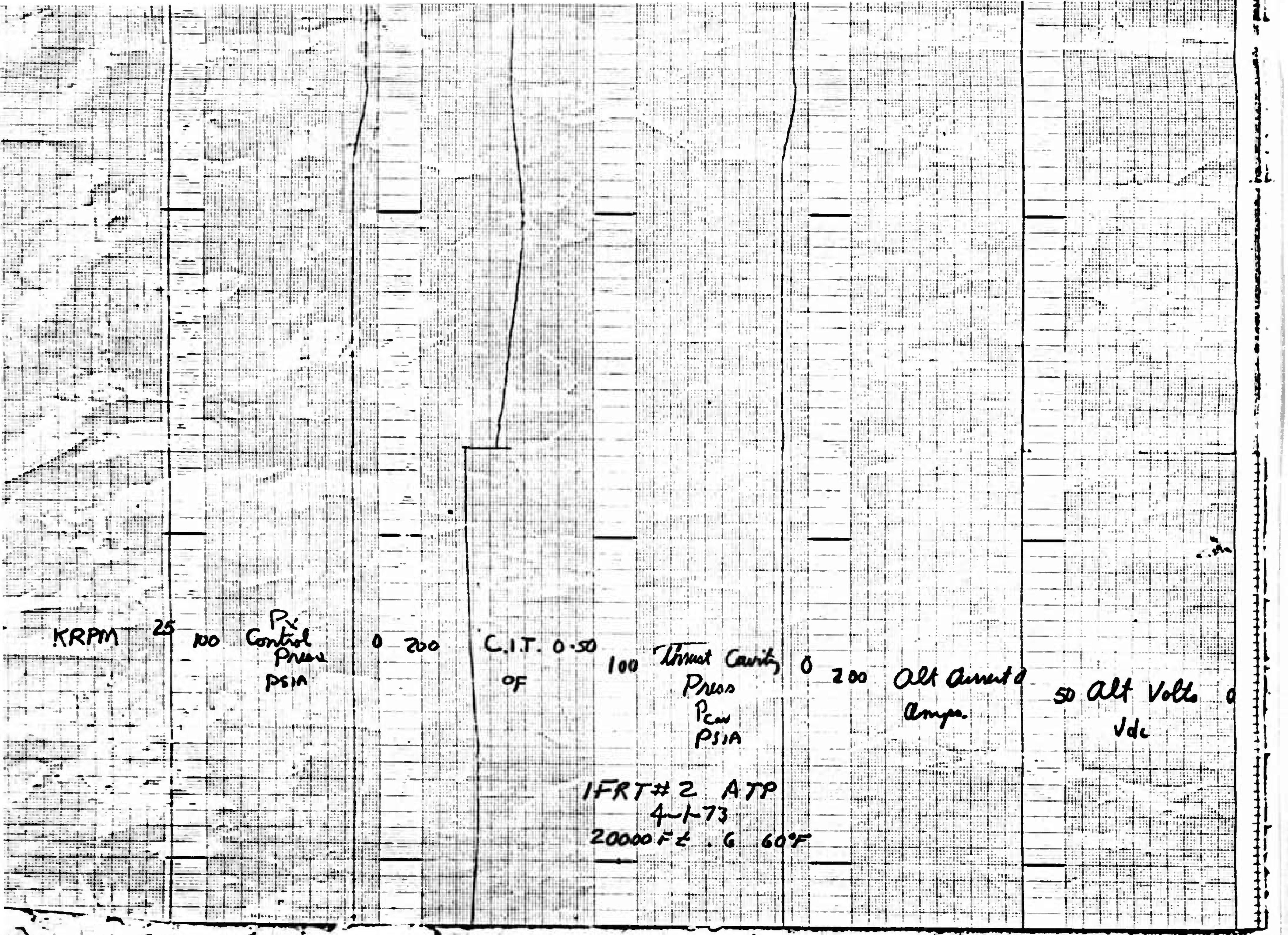

50 Engine Speed %RPM 0
100 Ps3 PSIA 0
100 Fuel Flow PPH 0
2000 TT7 °F 0
10 Ram ΔP PSID 0
5 Vibration Mils 0
1000 Front Brg Temp 0
1000 Rear Brg Temp 0
IFRT #2 ATP
4-1-73
20000 Ft .6 60°F

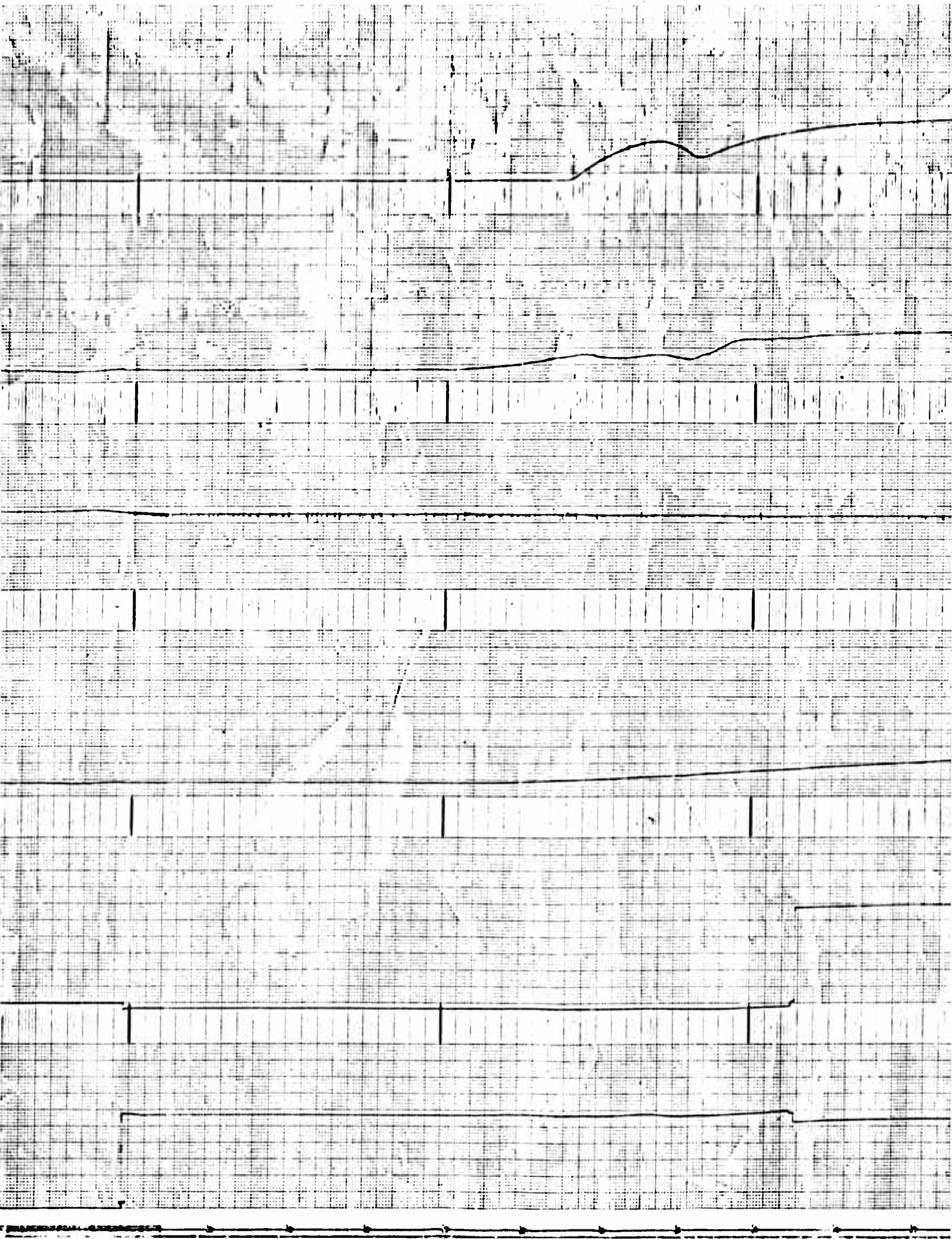


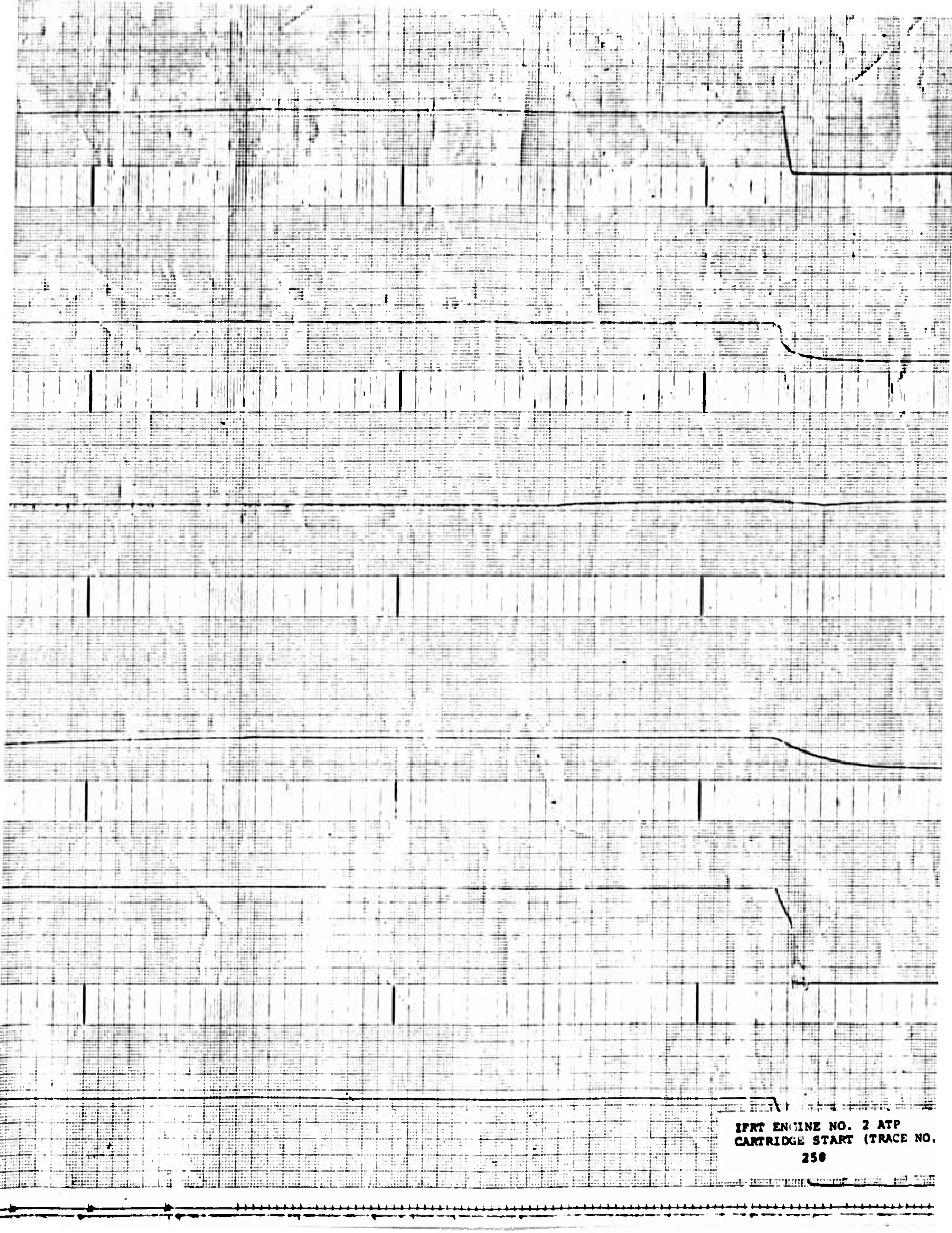


IFRT ENGINE NO. 2 ATP
CARTRIDGE START (TRACE NO. 1)

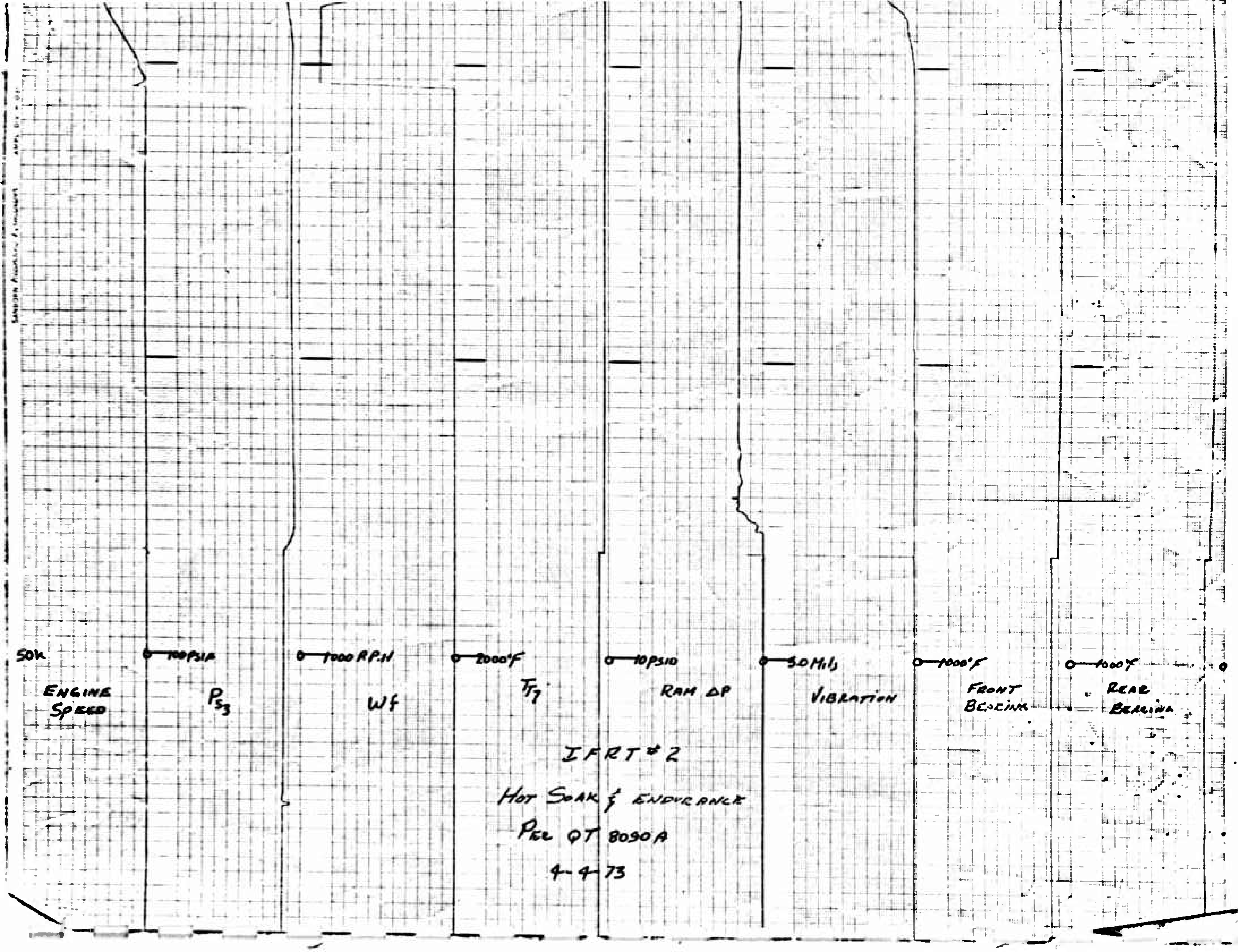
257


KRPM 25
100 P_c Control Press PSIA 0
200 C.I.T. 0-50 °F
100 Thrust Cavity Press P_{cav} PSIA 0
200 Alt Current 0 Amps
50 Alt Volts 0 Vdc
IFRT #2 ATP
4-1-73
20000 Ft .6 60°F

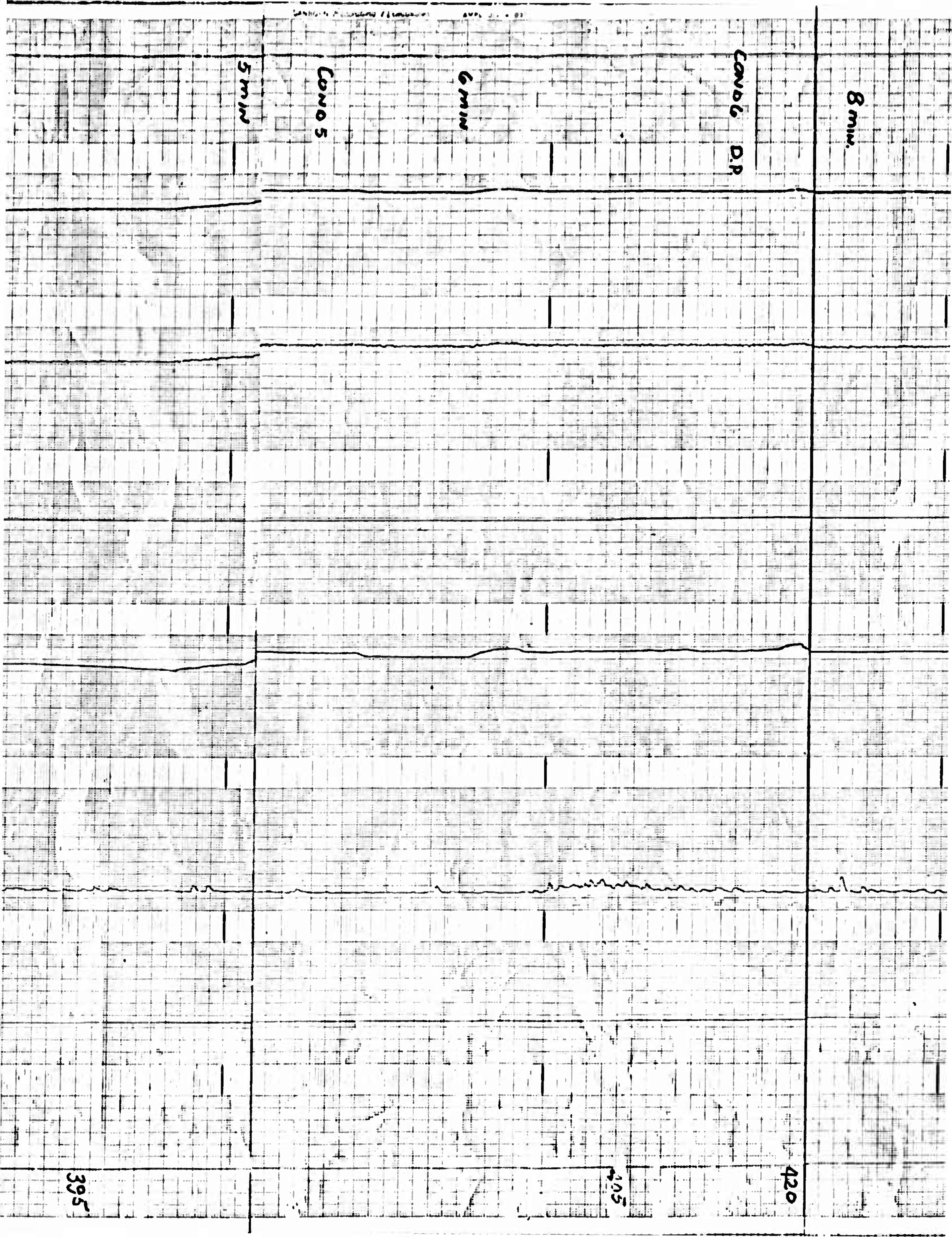




IFRT ENGINE NO. 2 ATP
CARTRIDGE START (TRACE NO.
258


50K
ENGINE SPEED
100 PSIA
P_{S3}
1000 RPM
Wf
2000°F
T_{T7}
10 PSID
RAM ΔP
5.0 MILS
VIBRATION
1000°F
FRONT BEARING
1000°F
REAR BEARING
IFRT # 2
HOT SOAK & ENDURANCE
PER QT 8090A
4-4-73

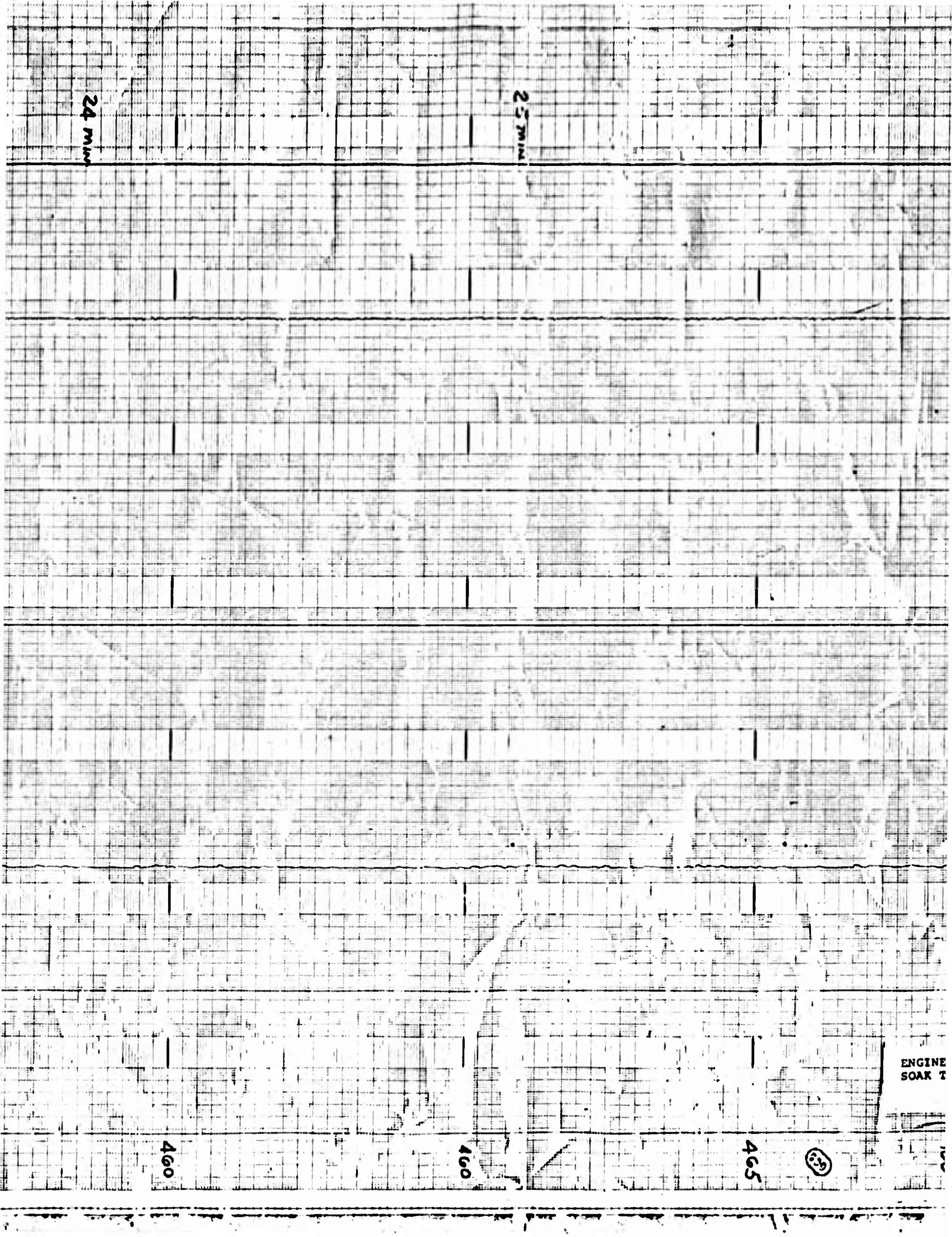

1 MIN
COND 2
2 MIN
COND 3
4 MIN
COND 4
340
260
300
320
340

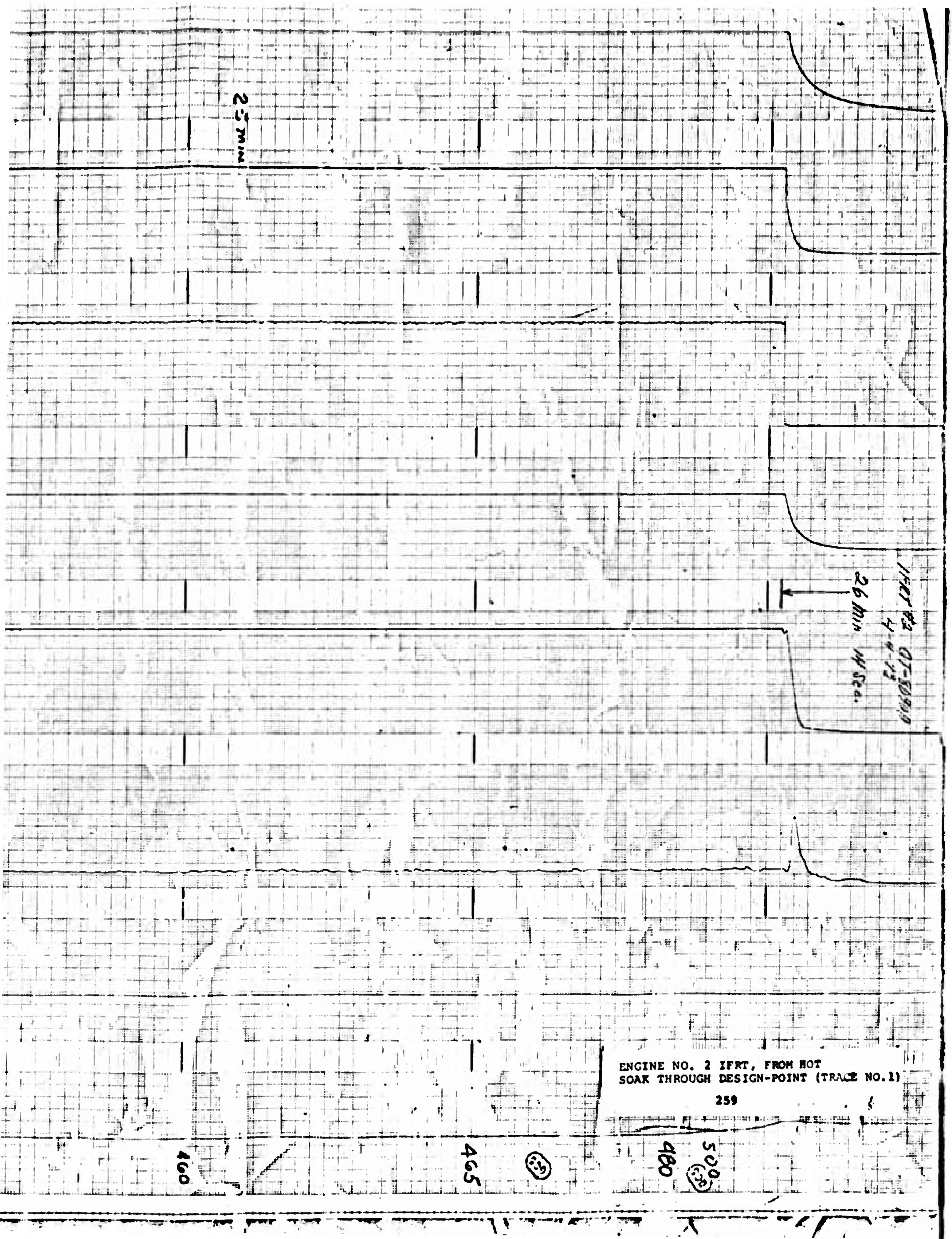


5 MIN
COND 5
6 MIN
COND 6 D.P.
8 MIN.
395
405
420

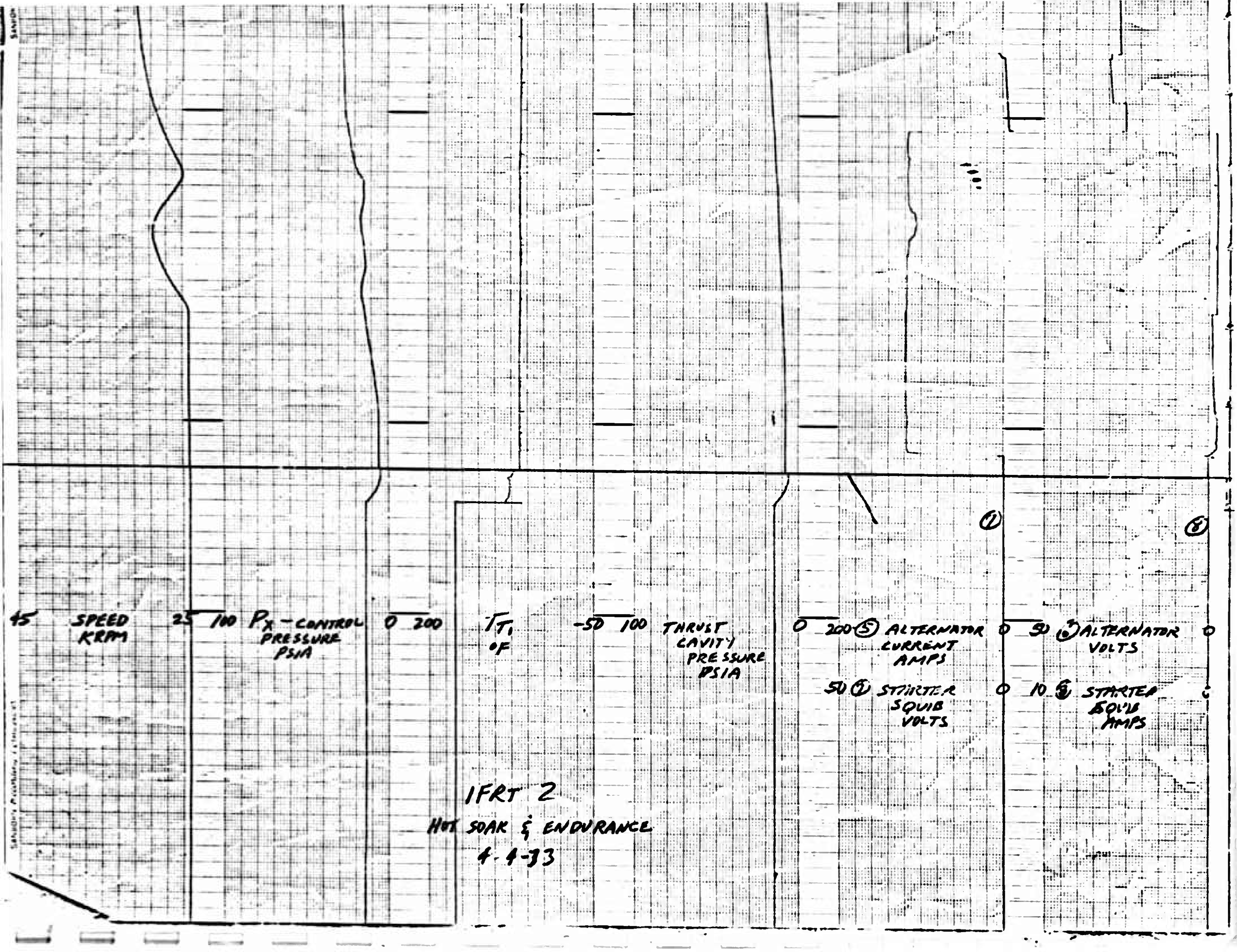

10 min
440
445
460


20 min
23 min
460
460
460
460

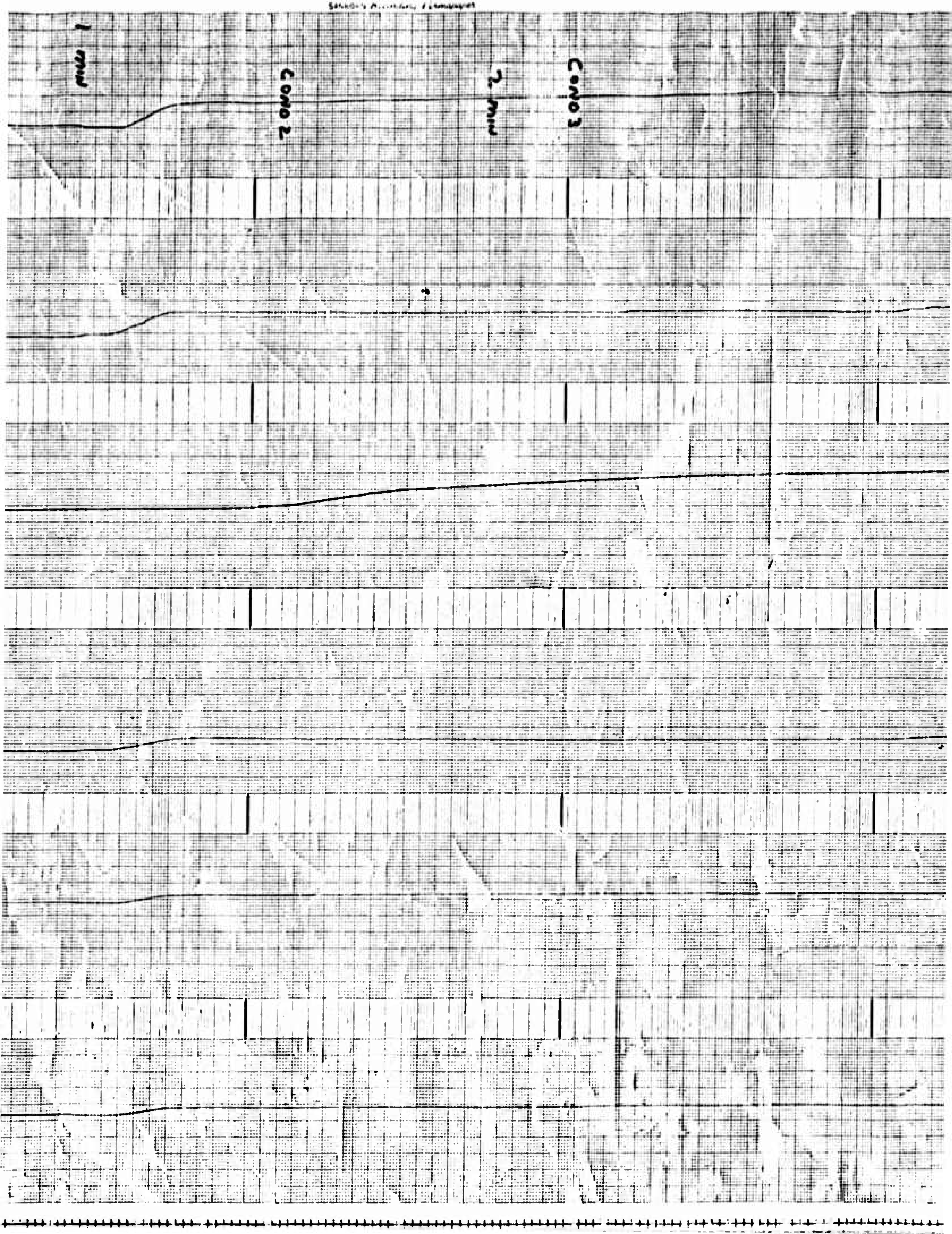

24 min
25 min
460
460
465
ENGINE
SOAK T

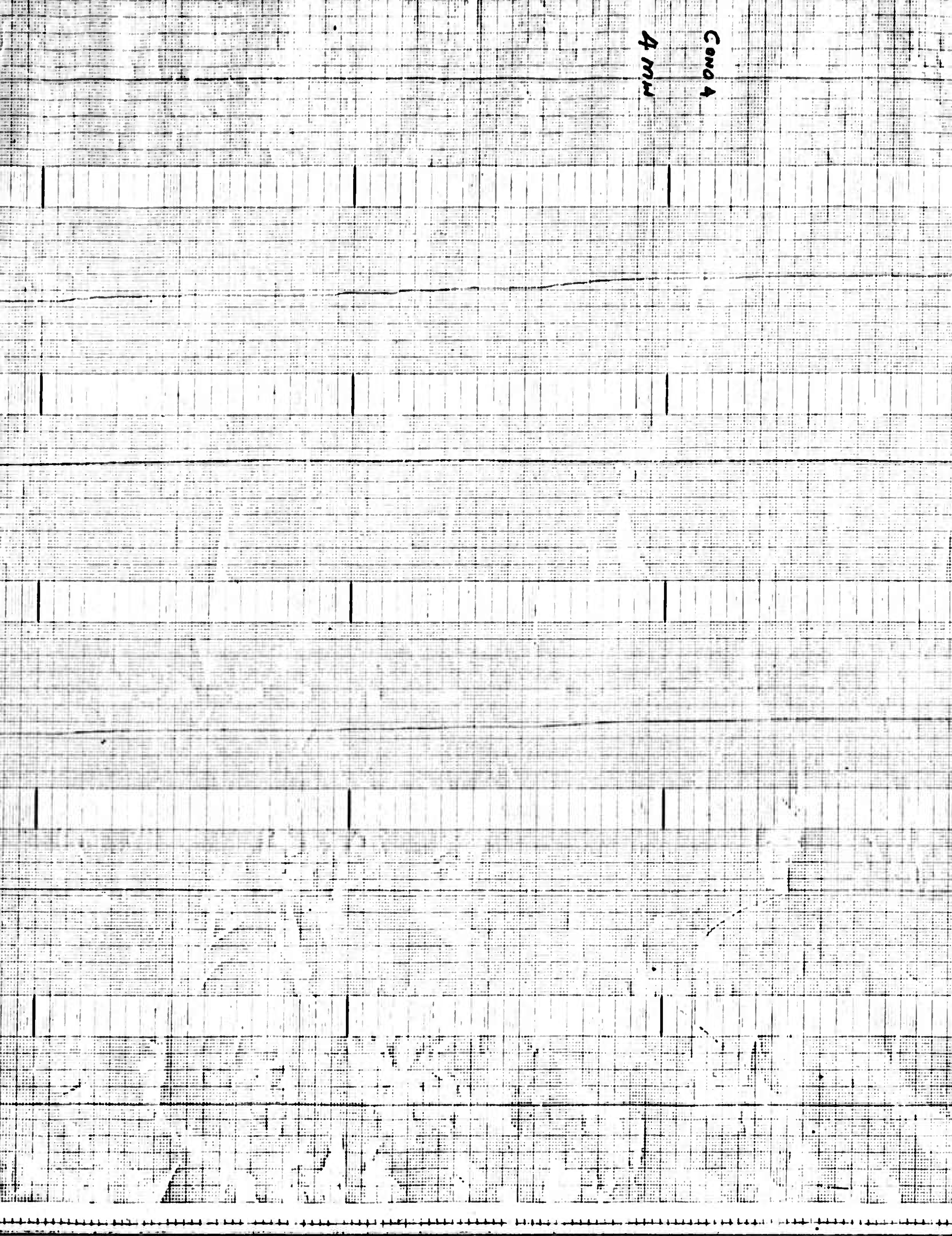


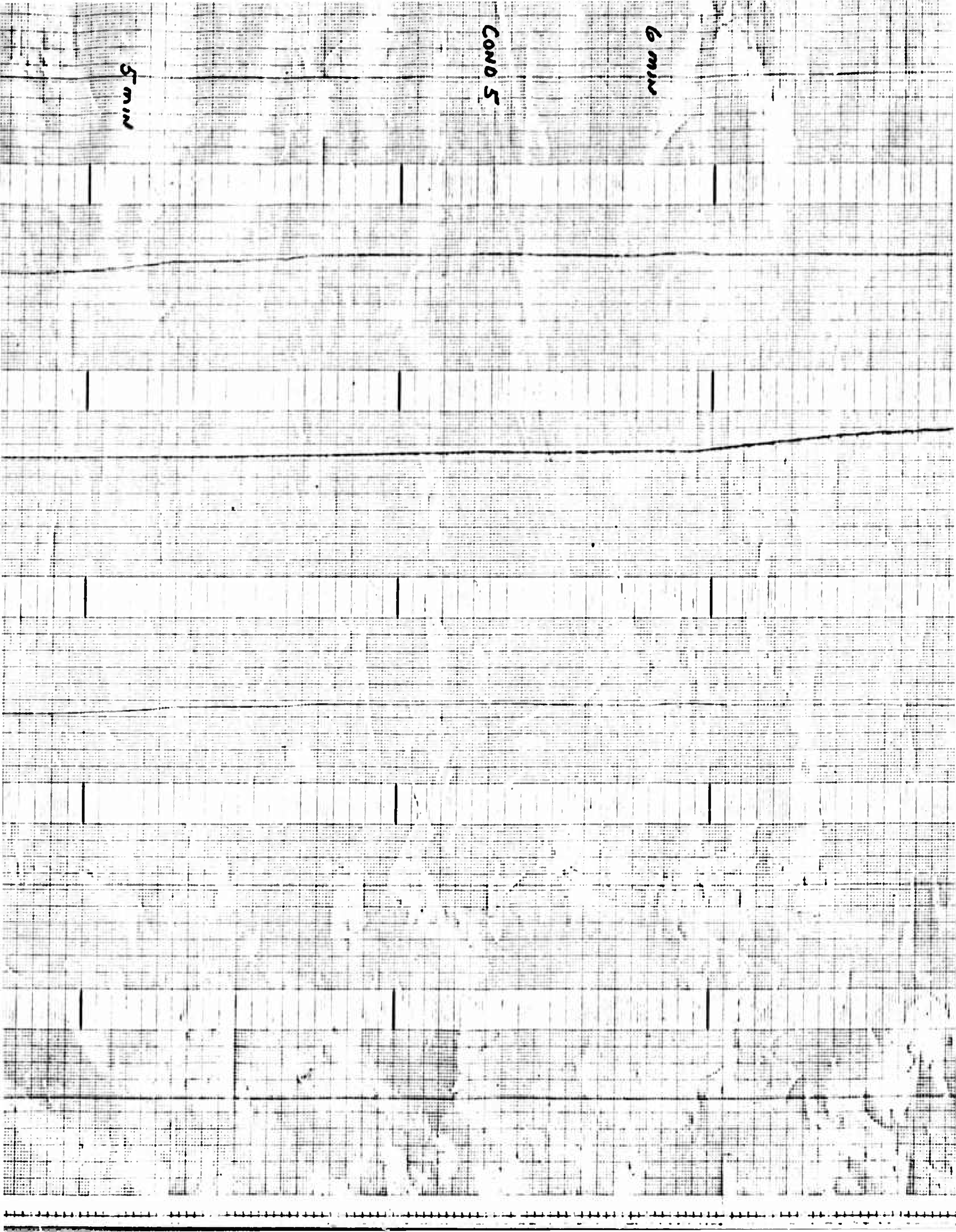
ENGINE NO. 2 IFRT, FROM HOT SOAK THROUGH DESIGN-POINT (TRACE NO.1)


45 SPEED KRPM 25
100 P_X-CONTROL PRESSURE PSIA 0
200 T_{T1} °F -50
100 THRUST CAVITY PRESSURE PSIA 0
200 (5) ALTERNATOR CURRENT AMPS 0
50 (7) STARTER SQUIB VOLTS 0
50 (6) ALTERNATOR VOLTS 0
10 (8) STARTER SQUIB AMPS 0
(7)
(8)
IFRT 2
HOT SOAK & ENDURANCE
4-4-73

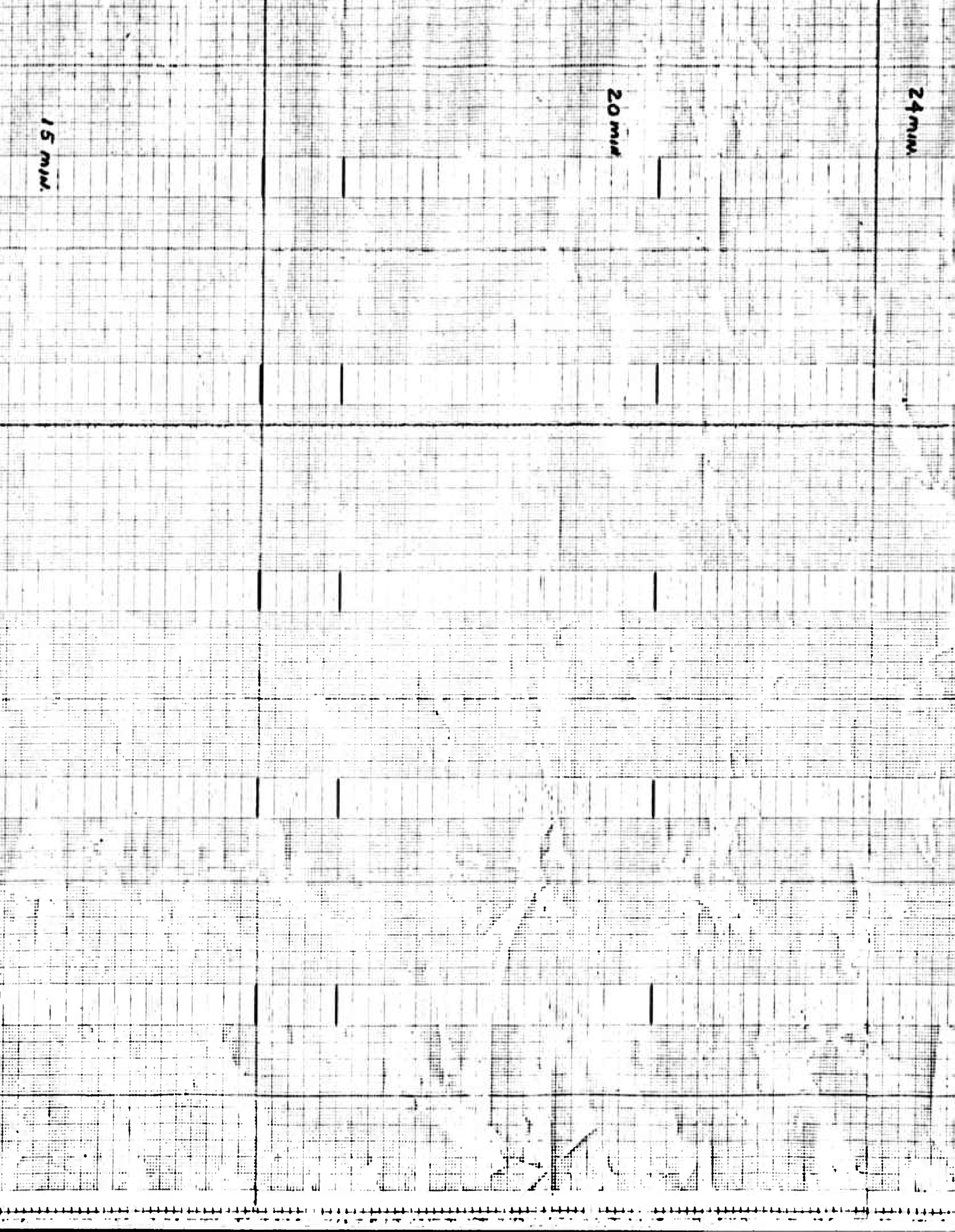

COND 1

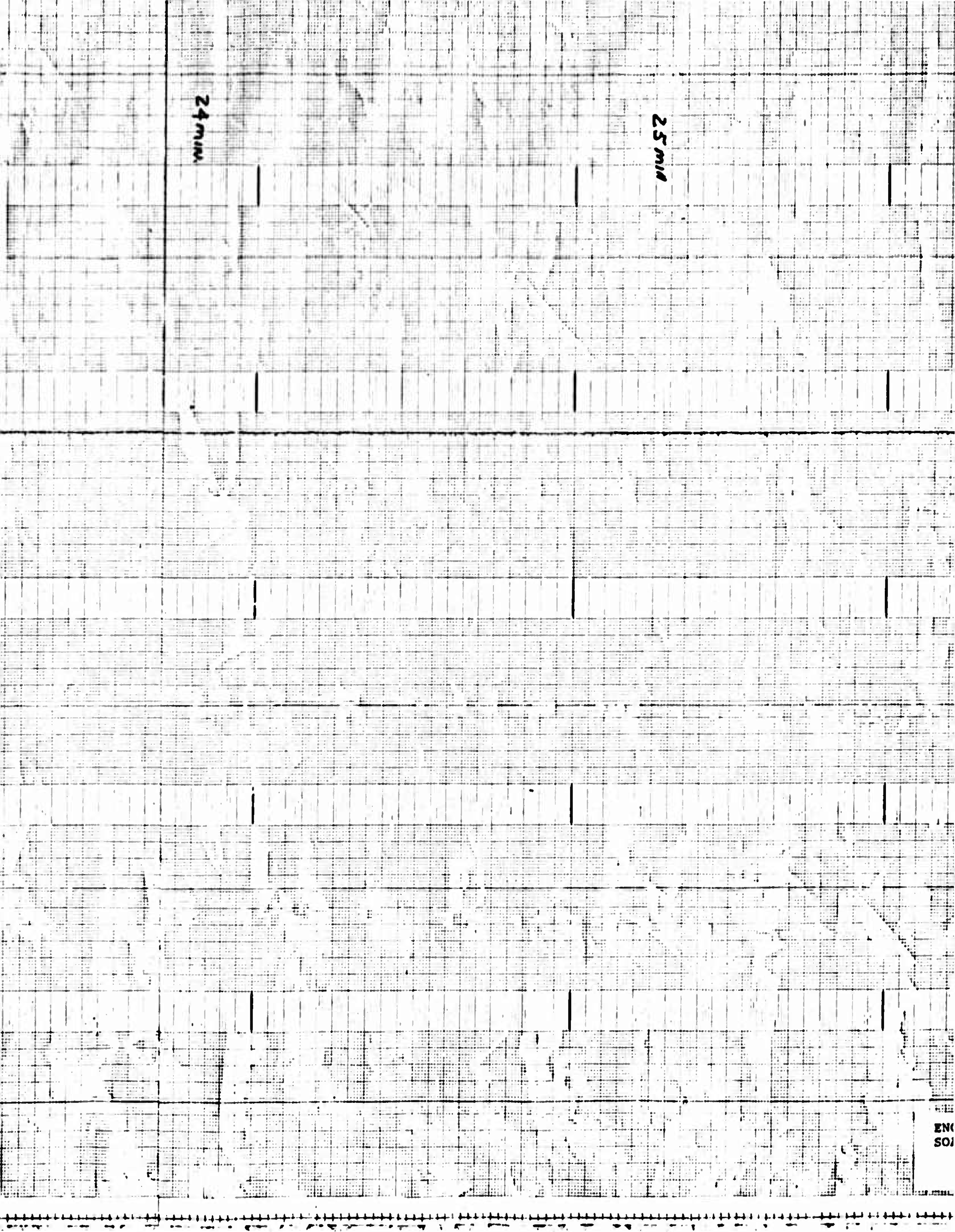

Min 1
Cono 2
2 min
Cono 3

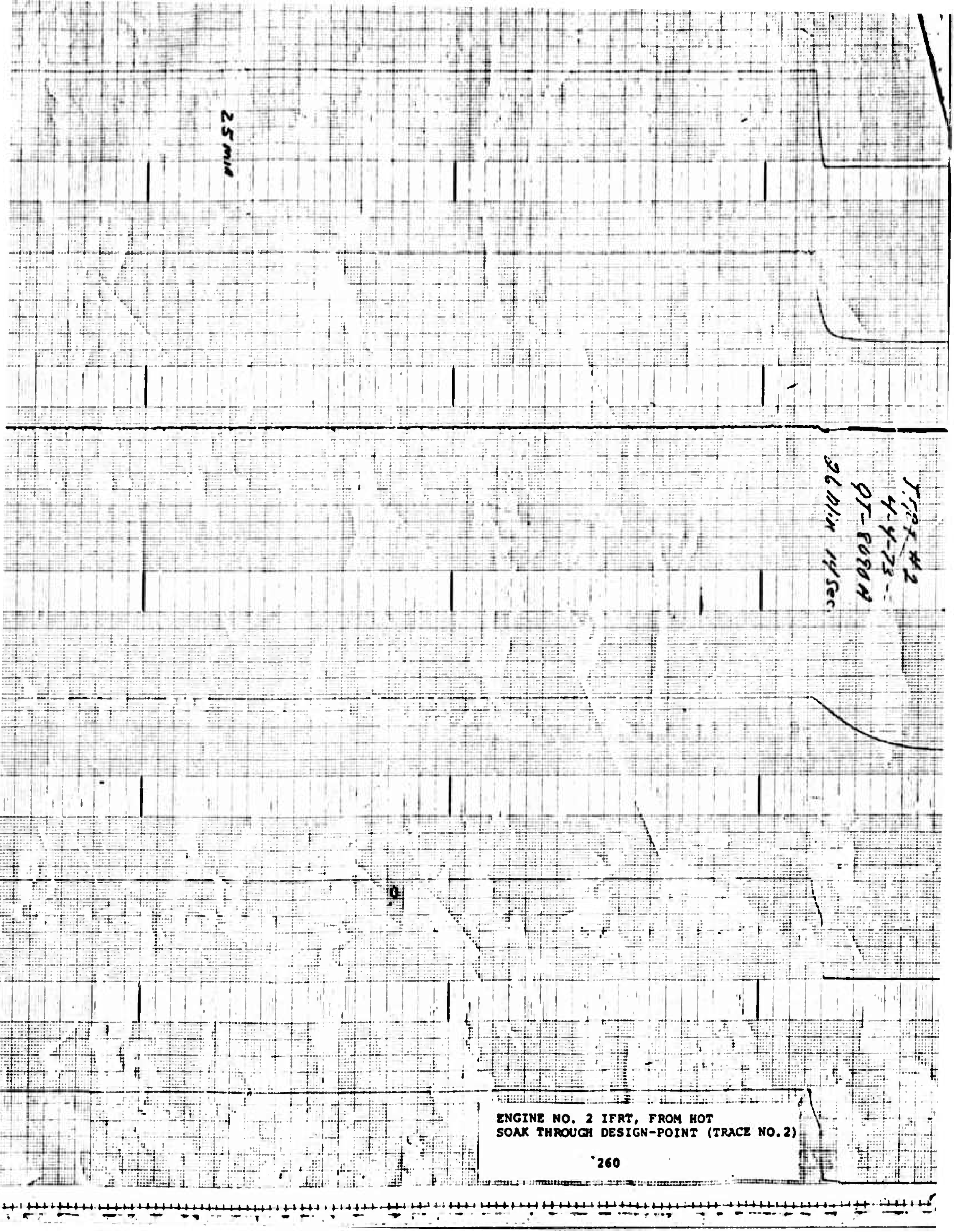

CONO 4
4 MM


5 min
COND 5
6 min


10 min
Con06 D.P.


15 MIN.
20 MIN
24 MIN.


24 min
25 min



ENGINE NO. 2 IFRT, FROM HOT
SOAK THROUGH DESIGN-POINT (TRACE NO.2)